Technical Report 1032

Evaluation of an Unaided Night Vision Instructional Program for Ground Forces

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13. ABSTRACT (Maximum 200 words):

An unaided night vision program for ground forces was developed to reduce current training deficiencies in instructional materials and the training literature. The program is presented in the dark and demonstrates visual problems at night and how to overcome them. Two experiments with experienced soldiers showed the program increased soldier knowledge by 40% regardless of Army experience and can be given effectively by military instructors. Content designated as more important was acquired better than less important content. The program had a stronger effect on demonstration-related and technical material than on soldiers' ability to apply night vision concepts to new situations. Baseline results with experienced soldiers showed their knowledge of unaided night vision was fragmentary and limited. An experiment comparing the program to a text version showed that Infantry trainees with low verbal ability benefited more from the program itself than the text version; trainees with high verbal ability benefited more from the text version. Relatively little forgetting occurred over a 3-week period. Knowledge gained from the program can be applied directly to improve soldier performance and to refine unit standard operating procedures for night operations.

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FOREWORD

Fighting at night has become increasingly important to combat success as new and better generations of night equipment allow soldiers to see and operate more effectively at night. The goal of the NIGHTFIGHTER program being executed by the Infantry Forces Research Unit (IFRU) of the U.S. Army Research Institute for the Behavioral and Social Sciences is to improve soldier, leader, and unit training for night operations. Research under NIGHTFIGHTER encompasses a broad spectrum of skills and issues, ranging from basic skills which do not require special equipment to the specialized skills demanded by the most sophisticated night technologies, and from training issues which have persisted over time to those emerging as night operations become more common.

The research reported here is on an instructional program which emphasizes basic unaided night vision knowledge and skills. Through the use of 35-mm slides with neutral density filters, students experience what happens to their vision at night and learn techniques to overcome visual problems encountered at night. The program was developed under separate Memoranda of Agreement with the Naval Aerospace Medical Research Laboratory and the Naval Aerospace and Operational Medical Institute. The report presents a series of experiments conducted by the IFRU which showed the program increased the proficiency of experienced soldiers, as well as Infantry trainees, and can be presented effectively by military instructors.

Research findings on the unaided night vision program have been presented to the command group at the U.S. Army Infantry Center and to all Army agencies which supported the research. The program has been demonstrated to the observer/controllers and the opposing force at the Joint Readiness Training Center (JRTC), to the command group of the 82d Airborne Division, to the Ranger Training Brigade, and to numerous visitors to the U.S. Army Infantry School dismounted Battlespace Battle Lab's Night Fighting Training Facility. It is being used by the opposing force at the JRTC, the 82d Airborne Division, and the Ranger Training Brigade. The program will be part of the Battle Lab's Night Fighting Training Facility and in the exportable training package to be distributed by the Battle Lab.

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SFC Wallace Holder, who presented the unaided program to several groups of soldiers, willingly gave of his time to master the material. His presentations were excellent; he executed the experimental design flawlessly. The authors owe much of the success of the research to him.

Lastly, the efforts of CDRs Michael Mittelman and David Still of the Naval Aerospace Medical Research Laboratory must be acknowledged. It was through their ingenuity and expertise that the aviation unaided night vision program was created. CDR Mittelman provided continuing support which lead to the final ground forces' version. The research reported here could not have been executed without his valuable assistance, interest, and commitment.

EVALUATION OF AN UNAIDED NIGHT VISION INSTRUCTIONAL PROGRAM FOR GROUND FORCES

EXECUTIVE SUMMARY

Requirement:

Knowing the principles of unaided night vision and how to maximize vision at night are fundamental to ground force night operations. Although formal instruction on unaided night vision has been an integral part of Army ground force training, this training did not exist in 1992 when the research was initiated. Current doctrine and training literature for ground forces published from 1984 to 1992 contained minimal information on this topic. Preliminary tests showed that soldiers did not understand many of the basic principles of night vision. Instances of night operations problems due to an apparent lack of knowledge by leaders were also discovered. The need to reduce training deficiencies in unaided night vision was evident. The research examined the effectiveness of an unaided night vision instructional program for ground forces. The program is given in the dark using 35-mm slides with neutral density filters. While the eyes gradually adapt to the dark, demonstrations show what happens to vision at night and techniques to reduce visual illusions and other problems encountered at night.

Procedure:

Two series of experiments were conducted. The first examined the extent to which the program increased soldiers' knowledge beyond their current training and experience. Soldiers with differing degrees of Army experience participated, and both civilian and military instructors were used. The second experiment examined the knowledge gained and retained from the program as compared to reading the same material with no exposure to the perceptual demonstrations, that is, a text version of the program. Trainees in Infantry one-station-unit-training participated. A baseline measure of trainee knowledge was also obtained. Within each experiment, soldiers and trainees were randomly assigned to experimental conditions. A front-end analysis of training requirements, a historical comparison of information on unaided night vision in Army field manuals, and a comparison of current field manuals to the training requirements and the unaided program were also conducted.

Findings:

The unaided night vision program substantially increased soldier knowledge. The same effects occurred with civilian and military instructors. Content designated as important was

acquired better than less important content. The program had a greater effect on information related to the program demonstrations and technical material than on soldiers' ability to apply night vision principles and concepts. The initial test given to the soldiers showed their knowledge of unaided vision based on field experience was fragmentary and incomplete, and did not vary with length of Army service. For the trainees, although the program was effective compared to baseline scores, overall results were the same as that with the text version. However, there was a consistent interaction over time with general technical (GT) scores on the Armed Services Vocational Aptitude Battery. Trainees with low GT scores benefited more from the unaided program than the text; trainees with high GT scores benefited more from the text. Apparently, the program helped the trainees with low GT scores because the auditory and perceptual aspects of the program compensated for their more limited reading skills whereas the text version did not. On the other hand, the text version capitalized upon the verbal and reading skills of the trainees with high GT scores. Relatively little forgetting occurred over a period of three weeks.

Utilization of Findings:

The unaided program was very effective with different soldier populations. Commanders should expect about a 40% increase in soldier knowledge regardless of amount of field experience. It can be presented effectively by military instructors. The research findings also suggest that soldiers with high verbal skills may learn the most by first reading about unaided night vision and then seeing the program. Soldiers with limited reading skills may learn the most by first seeing the program and then reading about night vision. Knowledge gained can be applied directly to improve soldier performance and to refine unit standing operating procedures for night operations.

EVALUATION OF AN UNAIDED NIGHT VISION INSTRUCTIONAL PROGRAM FOR GROUND FORCES

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EVALUATION OF AN UNAIDED NIGHT VISION INSTRUCTIONAL PROGRAM FOR GROUND FORCES

Introduction

Unaided night vision skills are basic skills for the ground soldier. Soldiers must have confidence and competence in operating at night with the unaided eye. The proliferation of night vision devices has not decreased the need for, nor the importance of, unaided night vision skills and knowledge. In fact, this knowledge and these skills are the foundation for effective use of night observation devices, and are necessary whenever troops are without devices or must use both unaided and aided vision to maximize performance.

A review of current Infantry field manuals revealed critical omissions in information about unaided night vision. Institutional courses for initial entry soldiers, non-commissioned officers, and officers contained no formal instruction on unaided night vision. In addition, a preliminary test of soldiers' knowledge of unaided night vision (U.S. Army Infantry School Dismounted Warfighting Battle Lab, 1993) revealed that soldiers did not understand many of the basic principles of night vision. Historical examples of the consequences of not knowing what affects eyes at night and how to maximize unaided night vision exist (Kaplan, 1967; Rostenberg, 1944; U.S. Army Board for Aviation Accident Research, 1967). Without continued training in this area, problems will continue on the battlefield at night, as indicated in interviews with the soldiers who participated in this research. For instance, different colored strobe lights have been used unsuccessfully to designate assembly areas on large landing zones. Soldiers and leaders were apparently unaware of what can happen to color vision at night, even with intense light sources at long distances. Leaders are sometimes reluctant to allow soldiers to wear sunglasses during daylight, unaware of the substantial increase in dark adaptation time which can occur when glasses are not worn. Cumulatively, these findings showed a need to reduce current training deficiencies in unaided night vision.

This report describes three experiments conducted during 1993, 1994, and 1995 on the effectiveness of an unaided night vision instructional program developed for ground forces (Dyer & Mittelman, 1995). The research was part of the Army Research Institute's (ARI) NIGHTFIGHTER program conducted by the Infantry Forces Research Unit.

Unaided Night Vision Requirements

A front-end analysis was conducted on what soldiers should know about unaided night vision, and how this information applies to field operations. The areas identified in this analysis were: the dark adaptation process, what happens to vision as illumination levels decrease, the blind spots in the eye (the normal or physiological blind spot and the night or central blind spot), color vision at night, visual acuity at night, protecting dark adaptation before and during night operations, visual illusions at night, and the relationship between night vision and the anatomy and physiology of the eye. Specifics on each area are presented in Appendix A.

As part of the front-end analysis, scientific literature on night vision was reviewed (e.g., Boff & Lincoln, 1988; Goldstein, 1989; Hood & Finkelstein, 1986; Tufts College, 1949). Articles in military journals on night vision which focused on ground forces (e.g., Neel, 1952; Skipper, 1978; U.S. Cavalry Association, 1943), aviators (e.g., Chapanis, 1945; Kaplan, 1967; Liljencrantz, Swanson, & Carson, 1942; Neel, 1961; Tuxbury, 1960; U.S. Army Board for Aviation Accident Research, 1967), and both audiences (e.g., Rostenberg, 1944) were examined. Army field manuals (FMs) were reviewed.

Unaided Night Vision in the Military Literature

Military Journals and Programs of Instruction

Information on how the eyes function at night is not new. Much research on dark adaptation was conducted in the 1940s and even the 1930s, as indicated in Hood and Finkelstein's (1986) review and the *Handbook of Human Engineering Data for Design Engineers* (Tufts College, 1949). No extensive reviews were found, however, on when and how these research findings on night vision were incorporated in military training and practice. In addition, a comprehensive review of the military training literature was beyond the scope of the current effort. Consequently, the information which follows should not be considered a treatise on the military's unaided night vision training, but it does provide a historical perspective on the subject.

Many findings from early research on unaided night vision seem to have been incorporated in military training and operations during World War II, particularly aviation training. Stevens (1946) reported that facts regarding Vitamin A and its relationship to night vision and the temporal course of dark adaptation were brought to bear on aviation training programs during World War II. It was research in the area of psychophysics which showed pilots could protect their night vision prior to flight by wearing special red goggles during the half hour prior to take-off. The red goggles protected the "red-blind" rod cells from the wave-lengths of light that sensitize them (blues and greens), thereby allowing the rod cells to dark adapt. However, the red light passing through the goggles was sufficient for cone cell vision, allowing pilots to see while preparing for take-off. The importance of the night blind spot was also incorporated in pilot training at this time, stressing the importance of using peripheral vision to aim at targets.

There are references (Tufts College, 1949) to Navy watchmen on ships using red goggles to maintain dark adaptation while reading bright indicators and charts. A rather detailed article by Liljencrantz et al. (1942), intended for Naval aviators, stressed how and why the rods and cones function differently at night (the sensitivity of the rods and cones to different wavelengths of light), the shape of the dark adaptation curve, how to protect dark adaptation, the use of red light and red goggles, that red markings on charts or guideposts will not be visible under red light and red goggles, blindfold drills for aviators, the impact of the night blind spot and the need to scan, keeping windshields clean to maximize visual contrast at night, diet, the use of oxygen at high altitudes, and the impact of fatigue, smoking, and drugs on night operations.

A later article by Chapanis (1945) was both practical and technical, citing military and nonmilitary research on unaided night vision. Included in the article were discussions on the differential sensitivity of the rods and cones to wavelengths of light (Purkinje shift), rate of dark adaptation, individual differences in dark adaptation, effects of sunlight and Vitamin A on dark adaptation, factors other than dark adaptation that influence the ability to recognize objects at night (size, contrast, length of time seen), red goggles, cockpit lighting, night binoculars, and visual illusions (autokinetic, size-distance).

During the Vietnam conflict, military articles on unaided night vision for aviators and on aviation accidents at night also appeared (e.g., Kaplan, 1967; Neel, 1961; U.S. Army Board for Aviation Accident Research, 1967). These articles stressed many of the points cited earlier by Liljencrantz et al. (1942) and Chapanis (1945), but were less technical. In addition, Neel (1961) mentioned the negative impact on dark adaptation of exposure to bright sunlight.

Unaided night vision research also influenced ground force operations and training (Neel, 1952; Rostenberg, 1944; Skipper, 1978; U.S. Cavalry Association, 1943). Neel's article contained the most details on night vision as well as ground force applications. However, references which cited a direct impact of scientific findings on ground force unaided night vision training and operations, comparable to the citations by Stevens (1946) regarding the use of red goggles and scanning techniques by aviators, were not found.

What has characterized previous Army unaided night vision training programs? Several publications described unaided night vision training conducted during the 1950s. The individual skills manual published after World War II, FM 21-75 (Department of the Army [DA], 1950) described indoor and outdoor training exercises. The indoor exercises, conducted in a blacked-out room, included a shadowgraph to present target silhouettes under varying levels of illumination, practice in scanning and using off-center vision to locate targets, and use of red lights and goggles to demonstrate preservation of dark adaptation under these conditions. The outdoor training was comparable, using natural terrain features and man-made objects which soldiers had to identify during a terrain walk at night; how the use of binoculars could improve night vision was shown. It was recommended that the outdoor training be conducted when the light was equal to that of a brilliant half-moon; brighter or dimmer levels of illumination were of no training value. In 1952, Neel reported that the Infantry School at Fort Benning, Georgia was "using a most practical demonstration of night vision; a skyline topped by objects including tents, tanks, vehicles, and troops. This skyline is exposed to the students under varying degrees of illumination, and they are asked to identify what they see" (pp. 25-26). Neel stressed that classroom applications must be followed by putting soldiers in the field at night and requiring them to perform their ordinary duties. He also indicated that one-third of all training in Korea at that time was conducted at night. Jones and Odom (1954) incorporated training on unaided night vision in experiments on shooting the M1 rifle at night. The training was described as follows: "In a blacked-out classroom with proper training aids, the soldier is shown, once again largely by his own performance and to his own satisfaction, how proper dark adaptation, off-center vision, night scanning, and confidence in his own eyes properly used will all aid him in the task of target detection at night" (p. 18).

More recent programs of instruction by the Army National Guard Mountain Warfare School (1990, 1986) also reflect some of these basic unaided night vision concepts. Night vision was included in lessons on night vision goggles (NVGs) and on night map interpretation terrain analysis. Unaided night vision topics in the goggle program of instruction were: the physiology of the eye including rods and cones, the three types of vision (photopic, mesopic, and scotopic), the dark adaptation process, how to protect dark adaptation, self-imposed stresses on the ability to function well at night and on night vision, and night viewing techniques. The terrain analysis lesson used 35-mm slides to show how terrain features are affected by reduced illumination, and how soldiers can make the best use of the contrast cues available when navigating.

The details on night vision in each of these publications vary. Several topics were found in most, but other topics critical to ground forces were not common or were absent. Common areas were scanning techniques and off-center vision, how to protect dark adaptation during night operations (avoid lights, use red light, close one eye), the dark adaptation process, and the physiology of the eye. Less commonly mentioned topics included the degree of visual acuity at night, how colors are perceived under varying levels of illumination, why maps need to be made red-light readable, rhodopsin, how sunglasses can protect dark adaptation, and the effect of NVGs on dark adaptation.

Currently, there is no formal program of training on unaided night vision for ground forces in the institutional courses for Infantry trainees, non-commissioned officers, and officers. As part of the NIGHTFIGHTER front-end analysis on night operations, soldiers were asked whether they had received any training on unaided night vision. Responses ranged from the privates who said the only thing they had been taught is to close one eye when firing a rifle, to senior NCOs who had it in basic training, to other senior leaders who said they had not heard about unaided night vision since Vietnam.

Army Doctrine and Training Literature on Unaided Night Vision

To better determine what information has been and is currently available on unaided night vision to ground soldiers, Infantry field manuals (FMs) from the 1950s to the present were reviewed. This review showed changes in the coverage of unaided night vision in the doctrine and training literature over time as well as some errors and misleading or incomplete statements about night vision. Current information is limited to scanning techniques, visual acuity, and the time to dark adapt. Color perception, visual illusions, how to protect dark adaptation before operations, the night blind spot, distances at which light sources can be seen at night, and how the eye functions at night are omitted in the current manuals. In fact, some areas (color perception, visual illusions, night blind spot, how the eye functions at night) were not covered well in any of the ground force manuals examined.

The following Department of the Army (DA) doctrine and training manuals for ground forces were examined:

- FM 21-75 (1950), *Combat Training of the Individual Soldier and Patrolling*
- FM 21-75 (1967), *Combat Training of the Individual Soldier and Patrolling*
- FM 21-75 (1984), *Combat Skills of the Soldier*
- TC 7-1 (1976), *The Rifle Squads: Mechanized and Light Infantry*
- FM 7-8 (1980), *The Infantry Platoon and Squad (Infantry, Airborne, Assault, Ranger)*
- FM 7-70 (1986), *Light Infantry Platoon/Squad*
- FM 7-8 (1992), *Infantry Rifle Platoon and Squad*
- FM 7-92 (1992), *The Infantry Reconnaissance Platoon and Squad*
- FC 90-1 (1985), *Night Operations*
- TC 21-305-2 (1990), *Night Vision Goggles: Training Program for Night Vision Goggle Driving Operations*
- FM 23-9 (1989), *M16A1 and M16A2 Rifle Markmanship*

The FM 21-75 series focuses on individual skills. The FM/TC 7-X series deals with the Infantry platoons and squads. The FC 90-1, which is no longer current, was the only publication for ground forces which had night as its sole focus. Company-level FMs did not contain information on unaided night vision.

The following Army aviation manuals were reviewed:

- FM 1-301 (1987), *Aeromedical Training for Flight Personnel*
- TC 1-204 (1988), *Night Flight: Techniques and Procedures*

Information on unaided night vision in the current ground force manuals was compared to that in their historical counterparts. Thus FM 21-75, dated 1984, was compared to the 1967 version, and the 1967 version was compared to the earlier 1950 version. The FMs 7-8 and 7-92, dated 1992, were compared to the previous manuals in the FM/TC 7-X series published from 1976 through 1986. Information in FC 90-1 on night operations was compared to that in the current platoon and squad manuals.

Frequently, earlier publications contained more information than the current manuals. The current FM 21-75 (1984), *Combat Skills of the Soldier*, contains limited information on unaided night vision. Only the rate of dark adaptation and off-center vision viewing techniques are discussed. On the other hand, the 1950 and 1967 versions of FM 21-75, *Combat Training of the Individual Soldier and Patrolling*, were more complete, including information on night scanning techniques, protecting dark adaptation, and the anatomy and physiology of the eye. Guidelines on night vision training were presented. A detailed comparison of these two documents is in Appendix B.

The two earliest squad and platoon manuals reviewed, TC 7-1 (1976) and FM 7-8 (1980), contained essentially no information on unaided night vision. However, the 1985 publication of FC 90-1 on night operations apparently influenced all the platoon and squad FMs which followed. The 1986 FM 7-70 on light Infantry platoons and squads repeated almost all the information on unaided night vision in FC 90-1. In turn, information on unaided night vision in the current 1992 platoon and squad FMs was apparently based on the 1986 FM, but some topics were deleted and other areas were condensed.

The 1985 FC 90-1 on night operations had information on the following topics: factors that influence the rate of dark adaptation; the night blind spot and its implications for scanning and recognizing objects at night; some guidelines on protecting dark adaptation before night operations and maintaining it during night operations; scanning techniques; limited information on visual acuity, color perception, and visual illusions at night; and some practical tips on night operations related to use of the unaided eye. The current manuals deleted information on the night blind spot, how to protect dark adaptation before night operations, and visual illusions. A detailed comparison of FC 90-1 and the platoon and squad manuals is in Appendix B.

Several errors and incomplete, and therefore misleading, statements made in FC 90-1 were perpetuated in the later manuals based on the FC. The most serious error was about colors at night. It was stated that blue lights are more difficult to see than red lights, and unlike red light, blue light does not hamper night vision. In fact, the opposite is the case. Red light is more difficult to see at night than blue light, and red lights do not hamper night vision. It was not clear whether the information in the manuals referred to the ability to discriminate between blues and reds, which is still possible with mesopic vision, or the ability to detect light from different colored sources even though the colors themselves cannot be seen, as is the case with scotopic vision. Under scotopic conditions, there is no color vision. But the rods are more sensitive to blue and green wavelengths of light than red wavelengths, making the former sources more likely to be seen from a distance, as white light, while the light from red light sources may not even be visible (i.e., the Purkinje shift).

The statement was also made that the eyes' sensitivity increases 10,000 times during the first 30 minutes of dark adaptation, but not much after that. In fact, the eyes' sensitivity increases 100,000 times over a 30 to 45 minute period (Boff & Lincoln, 1988, p. 6 & 148). This is a ten-fold increase in sensitivity over the 10,000 times cited in the manuals, which is more typical of 20 minutes of dark adaptation. The manuals correctly state that NVGs impede adaptation; if a soldier dark adapts before putting them on, dark adaptation is regained within two minutes after removal. These statements agree with the findings of Glick, Wiley, Moser, and Park (1974), where the AN/PVS-5 NVGs were worn for a period of five minutes. However, the manuals fail to mention that Glick et al. also stated that the re-adaptation time is a function of both the intensity and the wavelength of the NVGs. Extensive research on the effects of NVGs on dark adaptation remains to be conducted. Finally, a common statement in many manuals is that after exposure to flares, full recovery of dark adaptation may take up to 45 minutes; some manuals give a range band of 5 to 45 minutes recovery time. While these statements are not incorrect, a more complete description is that the time to recover depends upon the intensity of the light. With a low illumination white-light source, recovery can occur within five minutes; for a high illumination white-light source (equivalent to daylight), complete recovery can take more than 30 minutes (Boff & Lincoln, 1988, p. 158). On the other hand, if soldiers do not stare at short bursts of light from tracers or strobes, their dark adaptation will not be affected.

Information in the aviation manuals on night vision and night vision techniques is more thorough and technical than the current ground forces manuals (refer to Appendix B). TC 1-204 has an entire chapter on unaided night vision. Although pilots must be well trained in night vision techniques for their safety and the success of their missions, ground forces need just as much training and knowledge if they are to be proficient and confident in operating at night.

Because of omissions and incomplete statements in the current ground force manuals and other literature, soldiers and leaders have no source document for obtaining comprehensive and accurate information on the applications, techniques, and facts of night vision. Ground forces lacking this information cannot truly understand and appreciate why and how their eyes function at night, and how to maximize their night vision. In addition, leaders have not been provided with the information and materials they need for training their personnel.

The Unaided Night Vision Program

Description and Development

In 1989, the Navy (Mittelman & Still) developed an unaided night vision instructional program which focused on unaided night vision concepts and facts essential for aviators. The program is presented entirely in the dark, and can best be described as a lecture-demonstration (Taylor, 1988). It uses 35-mm light filtering slide technology, that is, neutral density filters, to allow individuals to dark adapt over the 45-minute instructional period. Neutral density filters decrease the intensity of a light without changing its color. The slides present basic information on unaided night vision, but the unique feature of the program is the demonstrations of night vision and illusions which are provided via the neutral density filters. While the eyes gradually adapt to the dark, demonstrations show what happens to vision at night and techniques to reduce visual illusions and other problems encountered at night.

The most dramatic illustration of the extent to which the eyes become more sensitive to light at night as a result of dark adaptation is illustrated by the very first and the very last slides. These two slides are identical. However, when the slide is first presented it is not visible because the eyes have not dark adapted. On the other hand, the slide is very clear at the conclusion of the program, as the eyes have become 100,000 times more sensitive to the dark than they were initially.

In 1992, the ARI's Infantry Forces Research Unit at Fort Benning, Georgia, initiated work with the Navy to modify the aviation program for ground forces and to determine its effectiveness. No evaluations of the aviation program had been conducted. This modified, or prototype, ground forces' program was used in the experiments described in this report. The basic structure of the aviation program was retained. However, demonstrations directed specifically for aviators were removed, and ground demonstrations were added. For example, in the aviation version, the illustration in the first and last slides was a helicopter caught in wires. The demonstrations in the program are described in Table 1.

Table 1
Demonstrations in the Unaided Night Vision Program

Demonstration	Description
Normal (Physiological) Blind Spot	Students scan a series of numbers and stop at the number which causes a large "X" to disappear in their peripheral vision - about 12-15 degrees off their axis of central vision.
Night (Central) Blind Spot	Demonstration 1. Students look directly at a dot of light. It disappears as they continue to stare at it. Demonstration 2. Students look at a model airplane as it is moves across the sky on a silhouette scene slide. Demonstration 3. Students look at the steeple of a church on a silhouette scene slide until the steeple disappears.
Technique to Overcome Night Blind Spot -- Diamond Viewing	A series of four dots create a diamond around the central dot in Demonstration 1. Students focus, in turn, on these four dots. The central dot then remains in view by using peripheral vision. Students use diamond viewing to maintain the airplane and the church steeple in the field of view.
Dark Adaptation - Increased Sensitivity of the Eyes	Contrast between the first and last slides which depict three attacking soldiers. Image not visible at first; clearly visible at end of program.

Table 1 (*continued*)

Demonstration	Description
Visual Acuity	Words on the slides are never completely clear because of reduced visual acuity during darkness. Slides simulate acuity typical at twilight. A silhouette scene using trees, buildings, radio towers, and telephone poles/lines illustrates the inability to discriminate details of objects at night.
Autokinetic Illusion	Single source of light is presented. It appears to move as students look at it.
Technique to Overcome Illusion	Apparent movement of the single light source is reduced by scanning back and forth between light sources. Two light sources presented to demonstrate this procedure.
<u>Color Vision</u> Level of Illumination	Demonstration 1. Two slides in sequence which show six colors under two levels of illumination. Under low illumination only shades of gray can be detected; under high illumination colors are distinct.
Purkinje Shift - Shift in sensitivity of retina from yellow-red to blue-green when going from light-adapted to dark-adapted state	Demonstration 2. A red and green dot are presented. As they are viewed with increasing reliance upon peripheral as opposed to central vision, the red loses its intensity and may fade away. Eventually the colors in both dots disappear and only white light can be seen.
Strobe Light - Effects of short bursts of light on dark adaptation	Strobe light turned on while students continue to stare at silhouette of terrain on the screen in front of them. Dark adaptation not affected as long as student does not look directly at strobe.
Flood Light - Effects of looking directly at an intense light on dark adaptation	Overhead lights turned on while student covers one eye and stares at the lights with the other eye. Overhead lights turned off, the covered eye remains closed, and students examine the terrain silhouette on the screen. Scene is now blurred due to loss of dark adaptation in the exposed or open eye. When the scene is then viewed with both eyes, the images are crisp and sharp because the dark adaptation in the covered eye has been maintained.

The script and the examples in the script were tailored to the ground force audience. Soldiers with extensive night operations experience were the source for most ground examples. After these soldiers observed the program, they were asked to give additional instances of the unaided concepts and perceptual demonstrations as well as other topics to include. Throughout program development, the Navy's expertise was used to ensure the scientific accuracy of the material.

An instructional objectives slide and four summary slides were added. The prototype ground forces' version, used in the experiments described in this report, had a total of 38 slides.

In addition, the instructional support in the guide was enhanced. As with the aviation version, an illustration of each slide was printed in the guide. In the aviation version, the text accompanying the slides provided guidance on how to conduct the demonstrations or simply repeated the word slides. In the prototype ground forces' version, the instructional purpose of each slide was added, as were the concepts and examples to be stressed by the instructor. More detailed instructions on how to give each demonstration were included. Finally, a suggested script for each slide was added. Both versions of the guide contained guidelines on how to prepare and set-up the classroom for the program.

Scope of the Program

The sequence of the program is as follows:

-Introduction
-Slide of troops, which cannot be seen
-Demonstrations of how colors change with varying levels of illumination
-Information on purpose of program
-Information on the eye; slides allow time for dark adaptation before the next demonstrations
-Information on the rod and cone cells
-Demonstration of normal (physiological) blind spot
-Demonstration of night (central) blind spot and diamond viewing technique
-Information on the three stages of dark adaptation
-Information on the dark adaptation process and the role of visual purple (rhodopsin)
-Information on protecting dark adaptation before night operations
-Information on protecting dark adaptation during night operations
-Demonstration of autokinesis
-Demonstration of the Purkinje shift (color perception)
-Demonstration of night blind spot and different effects of lights on dark adaptation
-Summary slides
-Slide of troops, which is now visible

Current ground force FMs were compared to the newly developed, unaided program in each of the areas identified in the front-end analysis. These comparisons (the front-end analysis, current FMs, and the unaided program) are delineated in Appendix C. The training program is more complete, accurate, and detailed than the FMs.

The primary focus of the program is on the acquisition of knowledge; that is, understanding the principles of night vision. Acquisition of night vision skills is secondary. The program stresses "knowing that" versus "knowing how," declarative versus procedural knowledge (Anderson, 1980). Because declarative knowledge provides the conceptual basis for procedural knowledge, acquisition of night vision skills should typically follow the acquisition of declarative knowledge. Jonassen, Beissner, and Yacci (1993) proposed an intermediate type of knowledge called structural knowledge, which is also reflected in the program. Structural knowledge refers to knowing why; knowing how concepts within a domain are related.

The front-end analysis showed a deficiency in the knowledge and understanding of night vision by leaders and soldiers, which was verified in the experiments reported here. Much knowledge gained from the program, both declarative and structural, can be applied immediately to night operations without extensive skill training. For example, leaders can establish standing operating procedures on the use of lights before and during night operations, what lights (colors and/or patterns) to use for marking and signalling, the wearing of sunglasses during the day, wearing prescription glasses at night, smoking before night operations, etc. Soldiers can look away from bright lights or close one eye to maintain dark adaptation. These acts are not hard to perform. What is needed is an understanding of the importance of such behavior and retention of this information so such actions will be executed when required.

The primary skill (i.e., procedural knowledge) covered in the program is diamond (off-center) viewing. The program explains this technique and shows why it is necessary. Students practice this viewing technique as well. Thus the first two stages of skill acquisition, the cognitive and associative stages (Anderson, 1980, p. 222), are covered by the program. How much practice is actually needed with diamond viewing so it will be performed in field settings, under conditions of stress and fatigue, was not addressed in the research. Silhouette recognition is discussed in the program; target detection and range estimation skills are not specifically addressed.

In summary, the program provides an understanding of how the eyes function at night, demonstrates the basic principles of night vision, and also provides practical guidance for operating in the field. It is intended to be a non-technical, yet complete source of information on unaided night vision for ground forces, and to fill a gap in the current suite of ground force training materials.

Effects of the Lecture-Demonstration Technique

The unaided program is a lecture-demonstration (Taylor, 1988), which uses special 35-mm slides to demonstrate perceptual phenomena. What are the advantages of this technique combined with this technology as compared to other techniques of instruction and media? Generally speaking, one medium is not inherently better than another (Salomon, 1979). Olson and Bruner (1974) postulated that individuals can learn from very different forms of experience, but that these forms qualify what is learned. This is not to deny, however, that common learning results from different forms of experience. For instance, soldiers acquire similar knowledge about the night blind spot from being told that objects can disappear or fade away at night when stared at as well as from being shown that this is the case by actually staring at objects under dark-adapted conditions. In fact, Olson and Bruner postulated that the differences in instructional techniques are not so much in the knowledge acquired, but in the skills involved in extracting or using that knowledge. For example, the skills required in deriving information from a perceptual task differ from those used in deriving information from language or print.

Salomon (1979) discussed media in terms of symbol systems. All forms of media convey content, but this content is structured and coded by symbol systems, which can be the same or different across media. Basic symbol systems are the linguistic (prose, poetry, technical language), iconic (photographs, drawings, sketches, graphs), musical, social-gestural, and logico-mathematical (Gross, 1974). Although different media use different symbol systems, the symbol systems used in these media are not mutually exclusive. There is commonality. However, some media seem well suited to certain symbol systems and to conveying certain types of information. For example, a map or a drawing is commonly used to direct a tourist to a specific location.

Salomon (1979) also postulated that symbol systems vary with regard to "(1) the amount of mental translation required for the extraction and processing of knowledge, (2) the kinds of mental skills required for that purpose, (3) the meanings one can construe from their messages, and (4) the mental skills they cultivate" (p. 64). In this regard, Salomon appears to agree with Olson and Bruner in that a major difference in instructional techniques is the skills which are acquired as learners interact with the symbol systems embedded in the instructional media. Consequently, in developing the criterion measures for the experiments reported here, there was an attempt to discriminate what was learned as a result of the perceptual demonstrations versus the verbally-presented program material and the text-only version.

The lecture-demonstration format, which combined the verbal and iconic symbolic systems, was viewed as essential to the unaided program. Presenting the visual demonstrations only would have been inadequate. The visual illusions and phenomena had to be described and explained. In another context using animated demonstrations of procedures, Palmiter, Elkerton, and Baggett (1991) found that the verbal component helped students understand the information and facilitated transfer to other tasks.

Salomon (1979) also distinguished the symbol systems available to a technology or medium from those which are actually used. Instruction should capitalize upon the technology. For example, a video-tape of an instructor presenting a classroom lecture serves primarily as a recording and transmission device, and does not take advantage of the capability of film technology. On the other hand, the use of 35-mm neutral density filters in the unaided night vision program was designed to take advantage of this particular technology by allowing soldiers to experience perceptual phenomena associated with different levels of limited visibility. The filters are varied to show colors under relatively high levels of illumination, where colors can be distinguished, as well as under lower levels of illumination, where only shades of gray can be discriminated. Red appears as black under low illumination, because of the contrast provided by the other colors surrounding it which appear as shades of gray. The filters are held constant on a slide used at the very beginning and very end of the program to show the change in dark adaptation which occurs over a period of 30 to 45 minutes. Through most of the program the amount of light is controlled to give soldiers visual acuity typical of twilight, that is 20/50. Thus the words on most slides are not always sharp; soldiers must use their peripheral vision to maximize their acuity and to avoid the night blind spot when reading the slides.

Although night vision phenomena can be described verbally or with prose, the visual medium seems particularly suited for conveying critical information about perceptual phenomena and enhancing soldiers' understanding of unaided night vision. The demonstrations could serve the representation and interpretation functions which Levin (1981) attributed to pictures or illustrations in text. When an illustration or picture serves the representation function, it makes the text more concrete. The interpretation function makes text more understandable or comprehensible. However, in order to serve these functions, the illustrations must be relevant to the instruction (Levin, 1981; Mayer & Gallini, 1990). This is the case with the unaided program.

The perceptual demonstrations were also expected to improve memory of the material. In some instances, the perceptual effects provided in the unaided program could be considered quite dramatic or vivid (e.g., the autokinetic illusion, effects of flood lights on dark adaptation, effects of the night blind spot). How do we retain visual information? Anderson (1980) argued that individuals typically remember the meaning of a picture or an illustration rather than the exact details, as postulated in Paivio's (1971) dual-code theory. Individuals remember an abstraction of a picture, just as they remember the meaning of sentences rather than the exact wording. Anderson argued that this abstract propositional code dominates long-term memory, although exact visual details can be remembered for long periods of time as well. Nevertheless, the memory for visual information appears to differ from that of verbal information (Anderson, 1980), with visual representations having a strong spatial structure and verbal a strong sequential structure. Because the unaided program provided both verbal and visual information for use as redundant, yet distinct, means of encoding and storing the program's content, retention was expected to be enhanced.

Lastly, "when people learn new information in the context of meaningful activities, they are more likely to perceive the new information as tools rather than as arbitrary sets of procedures or facts" (Cognition & Technology Group, 1992, p. 137). This is consistent with Ausubel's (1968) theory of meaningful learning, in that "new meanings emerge after a potentially meaningful learning task is related to, and interacts with, relevant ideas in cognitive structure on a nonarbitrary and substantive basis" (p. 52). Throughout the unaided program, soldiers are given examples relating the night vision concepts and principles to their missions and tasks. In addition, the examples were expected to aid memory in that they elaborated upon the basic concepts and principles of unaided night vision, thereby providing additional retrieval paths and redundancy (Anderson, 1980). Obviously, the general approach of relating abstract to concrete information (i.e., night vision concepts to events encountered in the field) is not unique to the 35-mm slide technology, but did make the program content directly relevant to ground forces.

Evaluations of Unaided Night Vision Training Programs

In 1952, Sharp, Gordon, and Reuder reviewed studies conducted in the 1940s on the effects of training on night vision ability. The intent was to determine, from previous studies, whether tests of night vision ability, night vision training, or both were required to obtain individuals with good night vision for key combat assignments. Reference was made in that report to a night vision test (ANVT-R2X) which showed some promise for personnel selection. Only five studies were found which examined the effects of training; none examined effectiveness as determined by performance in an actual field situation; all used laboratory test devices. No conclusions were drawn regarding the relative merits of testing and training in improving combat visual effectiveness. The authors did report that night vision training had been adopted by the United States, England, and Canada. This training purportedly consisted of practice in off-center vision, scanning techniques, proficiency in night recognition and range estimation, recognizing false visual impressions, and practice in allowing the eyes to recover from fatigue.

In a later report by Taylor (1960), four unaided night vision training programs were compared as part of experiments on detecting personnel targets at night. The baseline of no training was compared to three, two-hour training programs. The classroom training program covered topics on the history of night warfare, results of night vision research, physiology of the eye, the effects of dark adaptation, the need for off-center vision, the technique of scanning, and the importance of being confident at night. Forty minutes were spent in a dark room where soldiers used shadow boxes to practice what they had learned, were shown how red goggles and lights affect dark adaptation, and were shown the independence of night vision in each eye. The field training program consisted of two hours (30 trials) practicing, under conditions of no moon, to make discriminations about human figures (e.g., whether the individual was facing left, right, or forward; whether or not there was a target present). The third program combined the classroom and field training programs with one hour in each setting. The classroom training included the concepts most critical to perception at night and 30 minutes in a dark room; the field training was the same as the other group, but was reduced to 15 trials. No differences were found among the four training programs in soldiers' ability to detect individuals under full moon and no moon conditions.

Clark, Nadel, Johnson, and Dreher (1945) assessed Naval aviation cadets' knowledge of unaided night vision. Cadets with very little unaided night vision training, including some with no training, were compared to cadets who were tested immediately after receiving the "standard Evelyn lecture-demonstration" (p. 3) and to other cadets who were tested one to three months after the same training. The test covered the following topics: time required for dark adaptation, methods used for dark adaptation, readaptation time, protection of adaptation, use of red goggles and red light, off-center vision, false visual perceptions at night, loss of color vision at night, depth perception, and physiology of night vision. Cadets with no training answered 62% of the items correctly; those tested immediately after training answered 83% correctly; those tested one to three months after training answered 72% correctly.

Unfortunately, Clark et al. (1945) did not describe the "Evelyn lecture-demonstration," although apparently the demonstrations were conducted in the dark. Sharp et al. (1952) referenced the Evelyn trainer in their review, but again, a description of the training was not provided. Apparently, the Evelyn trainer was named after Wing Commander Evelyn of the Royal Canadian Air Force, and one purpose of the device was to train off-center vision. Sharp et al. indicated this device was used widely during World War II by the United States, Great Britain, and Canada. They reported that four, one-hour training sessions of air crews were evaluated by Evelyn and colleagues, who concluded that 50% to 75% of the air crews required only one training session to develop proficiency in off-center vision. Another 20% to 30% of the crews could profit from two or three sessions.

Research Purpose

The primary purpose of the research was to determine the effectiveness of the unaided night vision instructional program. Three experiments were conducted. The first two experiments examined the extent to which the program increased soldiers' knowledge of unaided night vision beyond their current training and experience. Soldiers with differing amounts of Army experience participated. It was expected that soldiers with more Army experience would gain more from the program. Both civilian and military instructors were used. This allowed an examination of program effects as function of instructor familiarity with the program content. The civilian instructor, a member of the research staff, was very familiar with the content, whereas the military instructor was not as familiar. The military instructor also provided an assessment of the potential of program success in typical Army settings.

The third experiment examined the knowledge gained from the program as compared to reading the same material, with no exposure to the night demonstrations. This was analogous to comparing what would be gained from reading a FM versus being exposed to a lecture-demonstration of the same concepts. Retention of the material as a function of these two instructional techniques was also examined. This experiment was conducted using initial entry soldiers with no prior Army training and experience in night operations.

The research was also designed to determine whether the important concepts in the program were learned better than the less important concepts, and whether the demonstrations themselves were effective. Answers to these questions were sought as they helped identify needed changes to the program, and they addressed the more conceptual issue of potential differences in instructional media, that is, a text presentation compared to an audio presentation combined with demonstrations of perceptual phenomena.

Comparison of Program to Current Training and Field Experience

The two experiments described here examined the extent to which the unaided program increased soldier knowledge of unaided night vision beyond that gained through previous Army classroom and field training. Experienced soldiers participated in each experiment, and the experimental design was the same in both experiments. However, in Experiment A, a civilian instructor presented the program; in Experiment B, a military instructor was used. The criterion test was a test of knowledge. The total score and subscores relating to the importance of the material and how the material was presented in the program were examined.

Experiment A: Experienced Soldiers and Civilian Instructor

Method

Research design. Soldiers who received the unaided night vision program, the Program group, were compared to those who did not, the No Program group (see Table 2). The design was a posttest only control group design (Campbell & Stanley, 1963). It specifies two groups, a test only condition and a treatment-test condition, with subjects randomly assigned to groups. This two-group, experimental design allowed an assessment of the extent to which the program increased soldiers' knowledge of unaided night vision (posttest scores for the Program group) over what soldiers from the same population had gained from their Army experience (initial test scores for the No Program group). However, in order to allow everyone to receive the program, this basic design was modified slightly, as indicated by the "follow-on activity" column in Table 2. Soldiers in the No Program group were given the program after taking their initial test and were then retested. No feedback on initial test performance was given to this group.

The posttest, initial test, and retest were the same. Program effects were determined by comparing the Program group's posttest scores to the No Program group's initial test scores. Changes from the initial test to the retest for the No Program group allowed an assessment of the combined effects of the initial test and the program.

Table 2
Research Design for Experiment A

<table>
<tr><th colspan="3">Experimental Conditions</th><th colspan="2">Follow-on Activity</th></tr>
<tr><td rowspan="2">R</td><td>Unaided Program</td><td>Posttest</td><td colspan="2"></td></tr>
<tr><td>No Program</td><td>Initial Test</td><td>Unaided Program</td><td>Retest</td></tr>
</table>

Note. "R" stands for random assignment to the Program and No Program groups. The design was applied to each group of soldiers.

The soldiers represented three different populations or categories: small-unit leaders from an active Army unit attending a course at Fort Benning, Ranger School students, and instructors and cadre from Fort Benning. There were 30 soldiers within each category, for a total of 90 participants. Within each category, 15 soldiers were randomly assigned to the Program group, and 15 were randomly assigned to the No Program group.

Procedure. While the Program group received the unaided night vision program, the No Program group took the initial test. While the Program group took the posttest, the No Program group was shown the unaided program and then retested. The program itself took 45 minutes to present. The experiment was replicated three times, once with each of the three categories of soldiers. The civilian instructor, a member of the research staff, was the same throughout the experiment. An audio tape was made of each presentation to check for consistency from session to session; little variation occurred.

The program was presented in a dark room in which all external sources of light had been blocked. Seating of individuals was in accordance with the instructional guide for the program (Dyer & Mittelman, 1995). The seating arrangement must be followed so all individuals can perceive the illusions. Three rows of seats with six individuals in each row provide the optimum layout. An additional row can be accommodated, however. Each row should be 10 ft (3 m) in length. The program is typically demonstrated to 15 to 24 people. The first row must be 10 ft (3 m) from the screen; the projector, 21 ft (6.4 m) from the screen.

Criterion measures. A 50-item test on unaided night vision was given (see Appendix D). The following topics were covered:

- general principles of dark adaptation
- the role of visual purple in dark adaptation
- protecting dark adaptation before night operations
- maintaining dark adaptation in the presence of different light sources
- the night blind spot
- viewing or scanning techniques
- the role of rods and cones in night vision
- how visual acuity is affected by reduced illumination

- the ability to see colors at night
- autokinesis, and
- reaction time at night.

Each item was categorized on two other dimensions: importance of the material, and how the item content was presented in the unaided program. The items assigned to these categories are documented in Appendix E.

Two importance categories were used: important and less important. These subscores were used to determine needed program revisions. The assumption was that if subscores covering less important material were higher than those covering more important material, the program should be revised as the more critical information was not being conveyed effectively. It was also of interest to determine whether soldiers with the most Army experience would score the same as those with less experience. Some items in each category are as follows. Item #39, which tested whether a soldier with 20/20 daytime visual acuity also has 20/20 at night, was classified as important, as all soldiers should know that everyone's visual acuity is impaired at night. Item #13 tested a more technical point on visual acuity, i.e., the best visual acuity possible on a moonless night, and therefore was classified as less important. Item #23, which asked soldiers to identify the most difficult color to see at night, a fundamental concept of night vision, was classified as important. Item #22, also on colors, was classified as less important, because it tested knowledge of color vision under the specific condition of twilight.

Three presentation categories were used to classify items: demonstrations, technical information, and application. Items tested either the night vision concepts and principles illustrated in the demonstrations, technical material which was typically presented only in a word slide or verbally by the instructor, or material which was not presented directly, but required application of concepts and principles in the program. It was of interest to determine whether subscores on items covering the demonstrations would be higher than those in the other two areas, technical and application. Some items in each category are as follows. Items #6 and #17 were both classified as demonstration items. Item #6 tested what to do to protect dark adaptation when suddenly exposed to a bright light; this was covered in the flood light demonstration. Item #17 addressed whether diamond viewing helps individuals to see stationary targets, moving targets, or both. In the program, soldiers use diamond viewing to help them see targets under both conditions. Items #1 and #14 tested technical information; how long it takes to dark adapt and the physiological reason for the night blind spot. Both topics were presented in the program, but only verbally by the instructor. Items #21 and #38 tested the soldiers' ability to apply concepts; that is, information not presented directly in the program. Item #21 required soldiers to determine which of several conditions would interfere most seriously with dark adaptation. Item #38 asked them to apply principles of color vision and to judge whether medics would find it hard to see blood on a casualty at night.

At the end, soldiers indicated the areas in which they had received previous training in unaided night vision. Again, it was of interest to determine if there were differences in these responses as a function of time served in the Army.

Results

Army background of soldiers. The three groups of soldiers were compared on time served in the Army and the rank held (see Table H1). There was a significant difference in time served in the Army, $F(2, 84) = 8.02$, $p < .0006$, with time in the Army for the small-unit leaders and instructors-cadre twice (5.9 years) that of the Ranger School students (2.7 years). A significant difference in rank also occurred, $\chi^2(6) = 45.91$, $p < .001$. Over 40% of the small-unit leaders and the instructor-cadre held the rank of sergeant or above; all the students were either specialists or lieutenants.

Posttest scores for the program group and initial test scores for the no program group. Table 3 displays the overall score, in terms of the percentage of items answered correctly. A two-factor ANOVA was conducted with program group and soldier category as the factors. There was a significant program effect, $F(1, 84) = 85.25$, $p < .0001$. The total score on the posttest for the Program group was 1.4 times higher than the initial score for the No Program group (71% versus 51% correct). The frequency distributions for the Program and No Program scores are displayed in Figure 1 (see Experiment B results). Ninety percent of the No Program group had scores of 60% or lower, while 84% of the Program group scored above 60%. The estimate of effect size, ϖ^2 (Hayes, 1973), was .49. In addition, there was no difference among the soldier categories. Of interest is that the three categories of soldiers did not differ on their initial knowledge of unaided night vision, despite the differences in time served in the Army (see the initial test scores for the No Program group in Table 3).

Table 3
Mean Percentage of Items Answered Correctly - Experiment A

Soldier Category	Group				Retest Scores for No Program Group	
	Program Posttest		No Program Initial Test			
	M	*SD*	*M*	*SD*	*M*	*SD*
Small-Unit Leaders	71	11	50	6	70	11
Ranger School Students	71	15	50	8	76	9
Instructors and Cadre	69	12	53	9	74	12
All Soldiers	71	12	51	8	73	11

Additional analyses were conducted to determine how test performance varied as a function of the importance of the content tested and how the program presented the content. Subscores on items which tested important content were compared to scores on items which tested less important content. Subscores on items which examined demonstration-related material, technical information, and application of concepts were compared.

Analyses of the importance and program presentation dimensions were based on the individual test items. Two additional analyses were performed in addition to the Program-No Program comparison on total score presented previously. Each analysis included program and soldier category as the two between-subjects factors; lower-order effects tested in the previous Program-No Program analysis were ignored. A three-way ANOVA was conducted with importance as the within-subjects factor. Only the main effect for importance and interactions with importance were examined. A three-way ANOVA was conducted with program presentation as the within-subjects factor. Only the main effect for presentation and interactions with presentation were examined. The ANOVA tables for these analyses are in Appendix H.[1]

There was a significant main effect for importance when both instructional groups were combined, $F(1, 84) = 81.25$, $p < .0001$. Higher subscores (see Table 4) were obtained on the items covering the more important content, $M = 68\%$ versus $M = 56\%$. The subscores were about 1.2 times higher on the important items. Such differences were expected if the program was effective in conveying critical points about unaided night vision. However, the results also showed that the soldiers who did not have the program, those in the No Program group, also scored higher on the important items; i.e., there was no significant interaction between the program and item importance factors. The effect of the program was simply to raise the level of both subscores; the relative discrepancy between the subscores remained the same for both groups.

It was expected that the demonstrations would be an effective instructional technique. There was a significant main effect for program presentation, $F(2, 168) = 28.42$, $p < .0001$. The subscores on the demonstration and applied items ($M = 69\%$ and $M = 61\%$ respectively, see Table 4) were each higher than the subscore on the technical items ($M = 57\%$). However, there was also an interaction between the program and presentation factors, $F(2, 168) = 16.73$, $p < .0001$. Subscores on both the demonstration and technical items were 1.5 times higher for the Program than the No Program group, 83% versus 54% correct for demonstration items and 68% versus 46% correct for technical items (see Figure 2 in the section on Experiment B). In contrast, subscores on the application items for the Program group were only 1.2 times higher, 67% versus 56% correct. Therefore, the program had a strong effect on items testing

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[1] Analyses were not conducted on the subscores resulting from the intersection of the importance and presentation dimensions (e.g., items on important and technical material; items on less important, technical material) due to the disparity in the number of items in these six categories. Means on these subscores are presented in Appendix H for descriptive purposes only.

Table 4
Mean Percentage of Items Answered Correctly by Item Classification - Experiment A

Item Classification	Group and Test			
	Program - Posttest[a]	No Program - Initial Test[a]	Program (posttest) and No Program (initial test) Mean[b]	No Program - Retest[a]
Importance				
Important	79 (14)	56 (12)	68 (18)	80 (12)
Less Important	65 (13)	47 (9)	56 (14)	68 (11)
Presentation				
Demonstration	83 (13)	54 (12)	69 (19)	80 (14)
Technical	68 (14)	46 (11)	57 (17)	74 (13)
Application	67 (16)	56 (13)	61 (16)	67 (11)

Note. All importance and presentation means and standard deviations were based on individual test items.
[a]$n = 45$. [b]$n = 90$.

information presented in the demonstrations and an equally strong effect on items testing the technical content, but it had a less strong effect on items addressing soldier ability to apply knowledge gained from the program.

Initial and retest scores for the no program group. Repeated measures ANOVAs were conducted to compare the initial and retest scores and subscores for the No Program group (Appendix H). Overall, the No Program group's scores increased significantly after receiving the program, $F(1, 42) = 158.17$, $p < .0001$. Scores increased from 51% to 73% correct, with the retest scores being 1.4 times higher than the initial test. Taking the initial test apparently did not affect the retest scores of the No Program group, as the total score was very similar to the posttest score of 71% correct for the Program group (see Table 3).

The change from the initial test to the retest on both the important and less important subscores was similar to the change on the total score, i.e., 1.4 times higher. However, changes were not the same for each presentation subscore, $F(2, 84) = 17.51$, $p < .0001$. The demonstration subscores increased by 1.4 times, from 54% to 80% correct; technical subscores increased 1.6 times, from 46% to 74%; application subscores increased only 1.2 times, from 56% to 67%. Retest means on the subscores are in Table 4.

Prior knowledge about unaided night vision. Soldiers were asked whether they had previously received unaided night vision training on ten different topics. Only one topic, general information about dark adaptation, was marked by at least half the soldiers. One-fourth or less indicated training in six of the ten areas. The exact percentages are in Table

H3. There was high agreement between the Program and No Program groups on the ordering of previous training on these topics, $r_s = .84$, $p < .002$.

The average score (% items answered correctly) for each of the ten topics covered in the program was also computed (Table H3). Data from the No Program group were used to address the question of whether previous training was related to the initial test subscores on these topics. These subscores did correlate significantly with the percentage of soldiers who indicated previous training on the different topics, $r_s = .76$, $p < .01$. In contrast, there was no significant relationship between the percentage of soldiers indicating previous training and the topic subscores obtained after soldiers had received the program; $r_s = .49$ ($p < .15$) for Program group and $r_s = -.43$ ($p < .21$) for No Program group.

Test reliability. Cronbach's coefficient alpha was used to calculate an index of test reliability. For the Program group, the coefficient for the posttest was .80. For the No Program group, the coefficient was .34 for the initial test and .73 on the retest. These results show that soldiers responded more consistently across items after having the unaided program.

Experiment B: Experienced Soldiers and Military Instructor

Method

In Experiment B, a military instructor presented the unaided program. This provided an assessment of the potential of program success in typical Army settings. It also provided an opportunity to see if the results from Experiment A could be duplicated with a less experienced instructor.

The experiment was replicated on two soldier populations. One was small-unit leaders from an active Army unit attending a course at Fort Benning; the other, a combination of leaders from an active Army unit and a reserve component unit, also attending a course at Fort Benning. There were 30 soldiers in the small-unit leader category and 32 in the active-reserve leader category, for a total of 62 participants. Within each category, soldiers were randomly assigned to a Program and a No Program group. The criterion measure was the same 50-item test used in Experiment A. The experiment was conducted twice, once with each category of soldiers, and was executed as described in Experiment A.

The military instructor had seen the program previously and had studied the instructional guide. The instructor was the same throughout the experiment. As was the case in Experiment A, an audio-tape was made of the presentation of the unaided program in each session. The instructor improved from the first presentation (small-unit leaders) to the second presentation (active-reserve leaders) by eliminating inconsistencies in content and providing a more complete explanation of technical terms.

Results

Army background of soldiers. Soldiers in the active-reserve component group had been in the Army significantly longer than the other group of leaders, $F(1, 57) = 14.02$, $p < .0004$, 10.9 years compared to 6.8 years (see Table H2). The active-reserve component participants were primarily staff sergeants, while the other small-unit leaders were generally of lower rank, being distributed among the ranks of specialist, sergeant, and staff sergeant, $\chi^2(3) = 19.21$, $p < .001$.

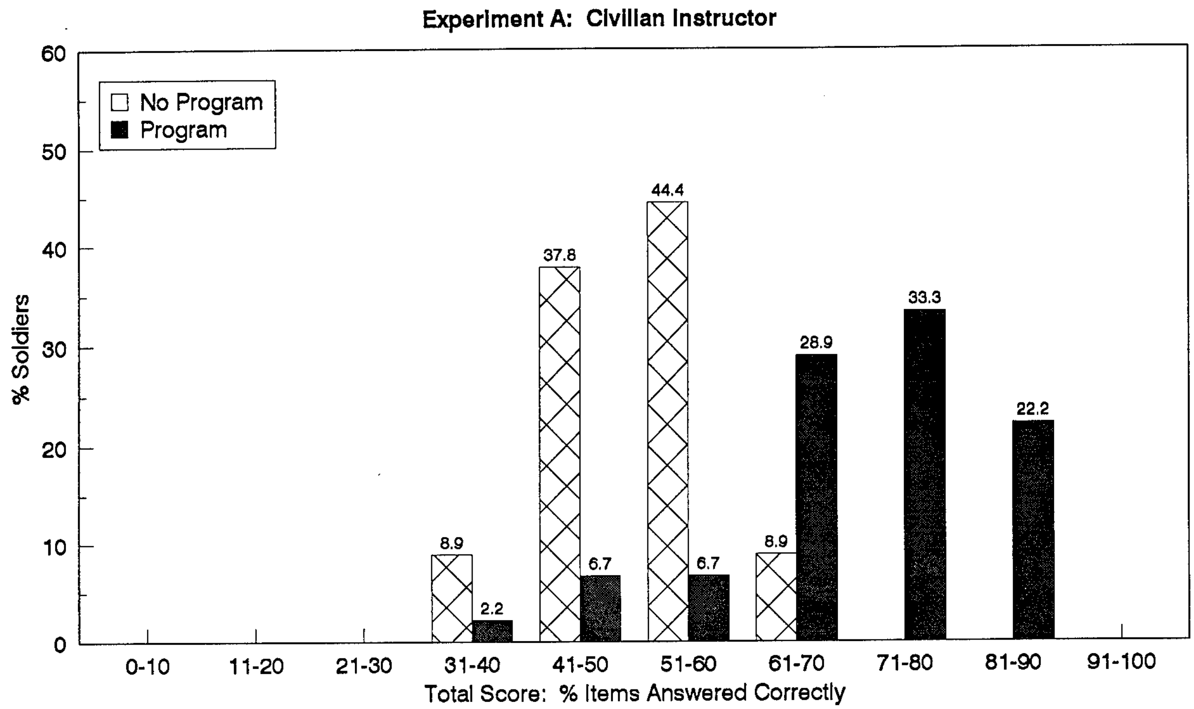
Posttest scores for the program group and initial test scores for the no program group. The results on total score paralleled those obtained in Experiment A (Table 5). There was a significant program effect, $F(1, 58) = 40.60$, $p < .0001$, with the Program group scoring 1.3 times higher on the posttest than the No Program group on the initial test, 66% correct versus 52% correct, respectively. The distributions of the Program and No Program scores are shown in Figure 1. The estimate of effect size, ϖ^2, was .39. There was no difference between the two soldier categories on total score. Again, the soldier categories did not differ on their initial knowledge of unaided night vision despite the differences in time served in the Army (see initial scores for the No Program group in Table 5).

Table 5
Mean Percentage of Items Answered Correctly - Experiment B

Soldier Category	Group				Retest Scores for No Program Group	
	Program Posttest		No Program Initial Test			
	M	*SD*	*M*	*SD*	*M*	*SD*
Small-Unit Leaders	63	11	51	7	72	8
Active-Reserve Leaders	68	8	53	8	72	8
All Soldiers	66	10	52	8	72	8

Analysis of the importance subscores showed a significant main effect when both groups were combined, $F(1, 58) = 37.06$, $p < .0006$. Higher subscores (see Table 6) occurred on the items covering the more important content, $M = 64\%$ versus $M = 55\%$. The subscores were about 1.2 times higher on the important items. There was no interaction between the program and item importance factors.

There was a significant main effect on the presentation subscores, $F(2, 116) = 8.74$, $p < .0001$. The demonstration and technical subscores, $M = 62\%$ and $M = 60\%$ respectively, were higher than the application subscores, $M = 54\%$ (see Table 6). However, there was also a significant interaction between program and the presentation subscores, $F(2, 116) = 15.26$, $p < .0001$. Subscores on both the demonstration and technical items were 1.4 times



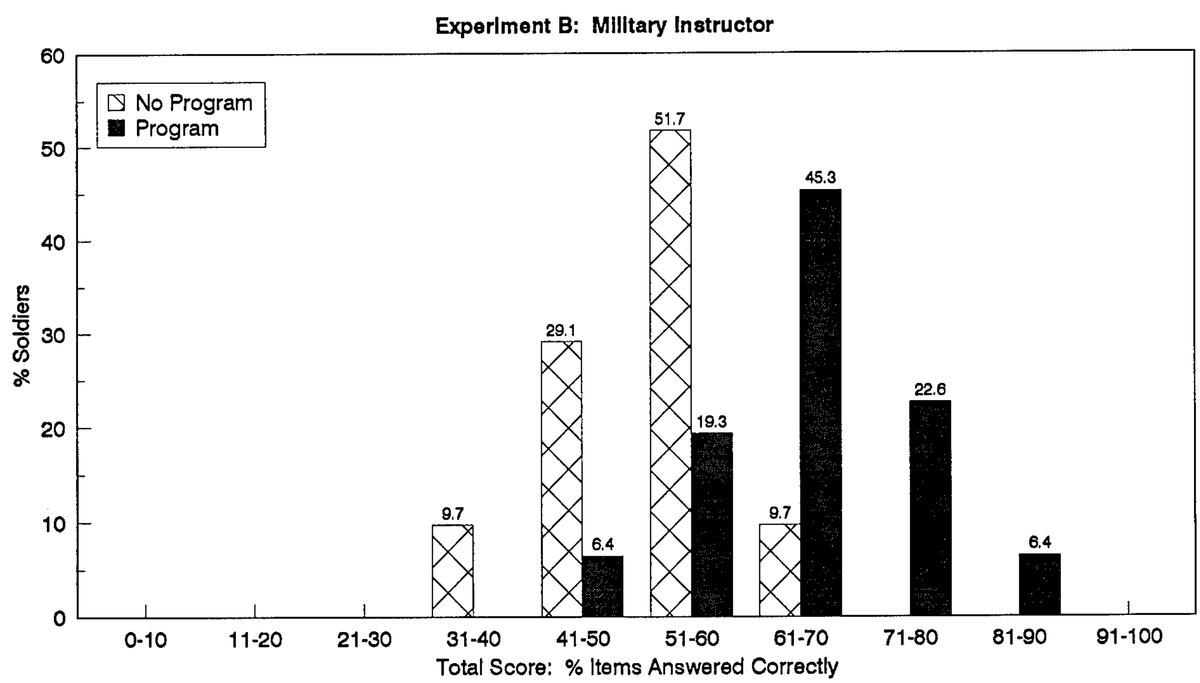


Figure 1. Distribution of scores for the Program group (posttest) and No Program group (initial test) in Experiments A and B.

Table 6
Mean Percentage of Items Answered Correctly by Item Classification - Experiment B

Item Classification	Group and Test			
	Program - Posttest[a]	No Program - Initial Test[a]	Program (posttest) and No Program (initial test) Mean[b]	No Program - Retest[a]
Importance				
Important	73 (11)	56 (13)	64 (15)	80 (10)
Less Important	61 (10)	49 (8)	55 (11)	66 (9)
Presentation				
Demonstration	72 (13)	52 (16)	62 (17)	78 (9)
Technical	70 (12)	51 (10)	60 (15)	72 (11)
Application	55 (11)	54 (10)	54 (11)	66 (14)

Note. All importance and presentation means and standard deviations were based on individual test items.
[a]$n = 31$. [b]$n = 62$.

higher in the Program than the No Program groups, 72% versus 52% correct for demonstration items and 70% versus 51% correct for technical items. In contrast, subscores on the application items for the Program group were the same, 55% versus 54% correct (see Figure 2). Therefore as in Experiment A, the program had a strong effect on items testing information presented in the demonstrations, and an equally strong effect on items testing the technical content. It had no effect on items addressing soldier ability to apply knowledge gained from the program.

Initial and retest scores for the no program group. As in Experiment A, a series of repeated measures ANOVAs compared the initial and retest scores and subscores for the No Program group (see Appendix H). The degree of change was similar to that in Experiment A. The No Program group had a significant increase in total score after receiving the program, $F(1, 29) = 253.27$, $p < .0001$. Scores increased 1.4 times, from 52% to 72% correct. The retest score for the No Program group was significantly higher than the posttest score for the Program group, $t(60) = 2.61$, $p < .01$ (72% versus 66% correct). This higher score may have been produced by the initial test which sensitized the soldiers to the program content. It could also reflect the instructor's inexperience when the program was given initially to the small-unit leaders (see Program results in Table 6).

The change from the initial test to the retest on the importance subscores showed that the gain was greater on the important items than the less important items, $F(1, 29) = 6.74$, $p < .0147$. Importance subscores increased 1.4 times, from 56% to 80% correct, whereas the

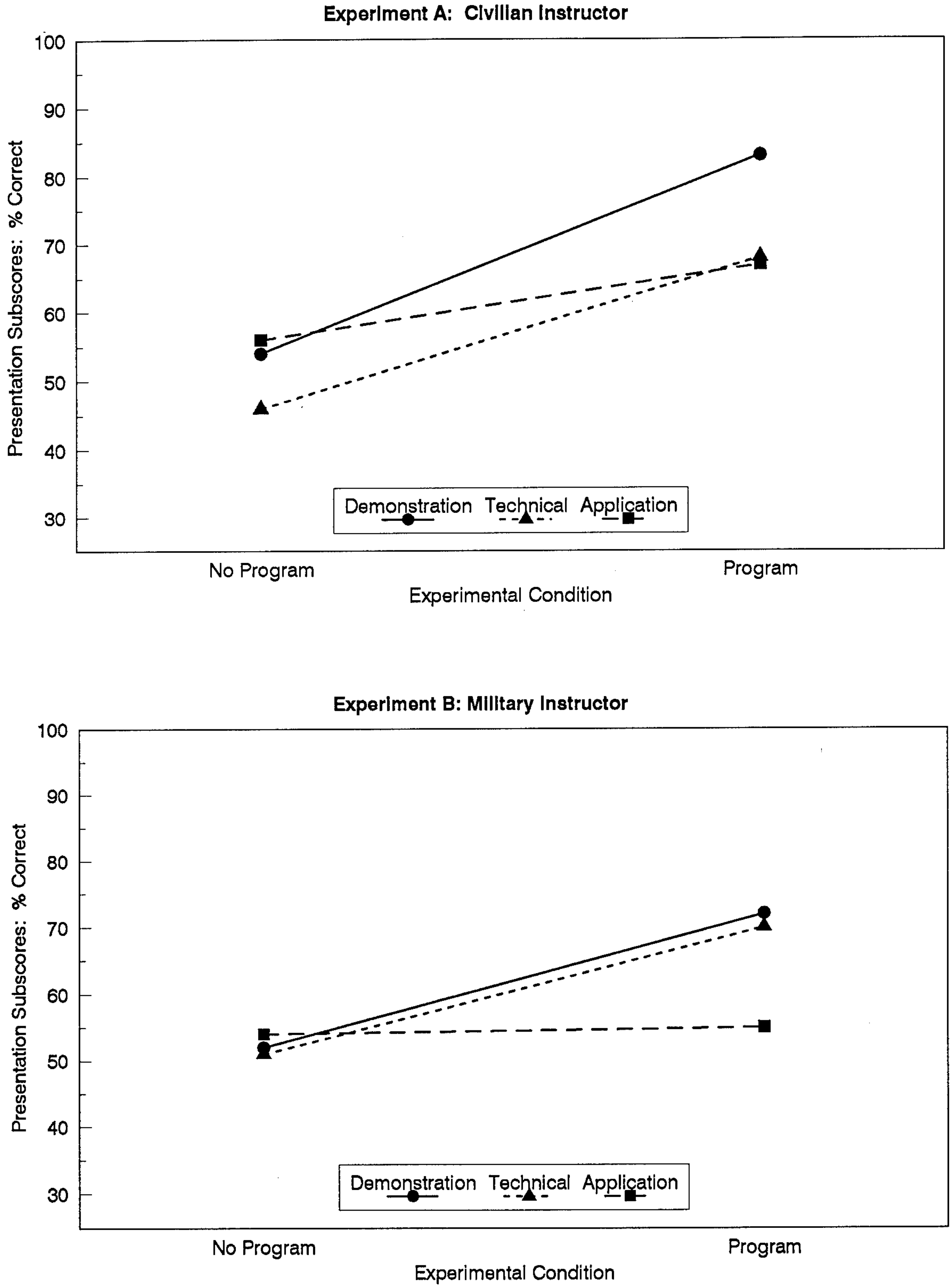


Figure 2. Interaction between experimental condition and program presentation subscores in Experiments A and B (Posttest for the Program group and initial test for the No Program group).

subscore on the less important items increased 1.3 times, from 49% to 66%. The relative amount of change on the presentation subscores also varied, $F(2, 58) = 8.69$, $p < .0005$. Demonstration subscores increased 1.5 times, from 52% to 78%; technical subscores increased 1.4 times, from 51% to 72%; and application subscores increased the least (1.2 times), from 54% to 66%. The degree of change on these subscores corresponded to that in Experiment A. Retest means on the subscores are in Table 6.

Prior knowledge about unaided night vision. As in Experiment A, soldiers were asked whether they had previously received unaided night vision training on the ten topics covered in the program. Only two topics were marked by at least half the soldiers, general information about dark adaptation and how dark adaptation is affected by lights. One-fourth or less indicated training in six of the ten areas. The exact percentages are in Table H4. There was high agreement on the ordering of these topics between the Program and No Program groups, $r_s = .90$, $p < .0001$.

As in Experiment A, the relationship between these indications of previous training and test scores was examined. Indications of previous training on the ten topics did not correlate with topic subscores from the initial test for the No Program group, $r_s = .42$, $p < .23$. In addition, for both groups, previous training did not correlate with topic subscores obtained after receiving the program; $r_s = -.36$ ($p < .38$) for the Program group and $r_s = .35$ ($p < .33$) for the No Program group.

Test reliability. Cronbach's coefficient alpha was used to calculate an index of test reliability. For the Program group, the coefficient for the posttest was .66. For the No Program group, the coefficient was .32 for the initial test and .58 on the retest. Although these indices are lower than those in Experiment A, they support the finding in Experiment A that soldiers responded more consistently across items after having the unaided program.

Discussion and Summary

The findings from both experiments were very similar. The major effects of the program were the same regardless of whether the unaided program was presented by a member of the research staff or by a military instructor. There was a strong program effect on the total score; the Program group scores on the posttest were about 1.4 times higher than the initial scores for the No Program group. In both experiments, subscores on items testing more important content were 1.2 times higher than those on less important items regardless of program condition. In addition, there was an interaction between the program and item presentation factors. The program resulted in higher subscores on items testing information presented in the demonstrations as well as on items testing technical material (approximately 1.5 times higher), but had relatively little effect on items addressing the ability of soldiers to apply knowledge gained from the program.

The test-retest results for the No Program group in both experiments paralleled the Program - No Program results. The total score increased about 1.4 times after taking the program. Scores on both the important and less important items increased on the retest. The presentation and technical subscores increased more than the application subscores. In Experiment A, the retest score for the No Program group was almost identical to the posttest score for the Program group, indicating that the pretest had no effect upon the retest scores for the No Program group. In Experiment B, the retest score was slightly higher, which may reflect a pretest effect, the initial inexperience of the instructor, or both.

Within each experiment, the test scores were similar after taking the program, regardless of Army experience. However, in related pilot work, higher scores were obtained with 16 Joint Readiness Training Center (JRTC) observer/controllers (O/Cs). Their total score was 79% correct after taking the program. On the average, these soldiers had been in the Army for 10.8 years. Of these 16, 63% were officers and 37% were noncommissioned officers.

Another important similarity in these two experiments was that the soldiers' initial knowledge of unaided night vision was the same regardless of Army experience and training, which ranged from an average of 2.7 to 10.9 years for the different groups of soldiers. Soldiers answered about half the items correctly.

Examination of the responses to individual items on the initial test showed that soldiers' knowledge was fragmentary. For example, soldiers knew that individuals dark adapt at different rates, but they did not know the length of time it takes to completely dark adapt, typically underestimating this period. They knew they should close one eye to protect their night vision from bright lights such as flares or search lights, but did not know how their night vision is affected by brief exposures to lights such as tracers, nor how long it takes to dark adapt again after exposure to different types of lights. They knew that staring at an object at night could make it disappear or fade away and that they should scan at night. However, they did not know the distances at which different sized objects are likely to be missed because of the night blind spot; what causes the blind spot; or that the night blind spot is exacerbated by conditions such as stress and fatigue when soldiers are likely to stare. They knew some circumstances where colors are difficult to see, such as blood on a casualty or colored smoke. Yet they did not know general principles regarding the perception of colors at night: which colors are hardest to see, which are easiest, and what happens to colors when viewed from a distance. They did not know how bad their visual acuity can be at night and the consequences of this for night operations. They did not know that prescription eye glasses should be worn at night to maximize visual acuity nor the procedures to follow to ensure the eyes will dark adapt at the normal rate.

These initial test results are consistent with the soldiers' indications of limited previous training on unaided night vision. In general, more than half indicated they had no prior training on eight of the ten topics covered in the program.

Comparison of Program to Text

Experiment C: Infantry One-Station-Unit Training

Experiment C compared the effectiveness of the unaided night vision program to a text version of the same material. The test items used in Experiments A and B were re-examined, and some items were added in an attempt to identify effects unique to these different modes of instruction. Although differences were not necessarily expected on the posttest, some differences were expected on the retention test. Participants were individuals who had just entered Infantry one-station-unit-training (OSUT) and had no military training.

Method

Research design. The comparison in this experiment was between trainees who received the unaided night vision program, the Program condition, and those who read a written version of the program script, the Text condition. Trainees were randomly assigned to the Program and Text conditions. The experiment was replicated twice. In the first session there were 22 in the Program condition and 23 in the Text condition; in the second session there were 18 in each condition. A total of 81 trainees participated. A retention test was given 24 days later. In this experiment, all individuals were new to the Army, in contrast to the experienced soldiers who participated in Experiments A and B.

In the Text condition, the material the trainees read was basically the same as what the instructor said during the Program condition. In other words, the text paralleled the script in the instructor guide. Some minor changes were made to the script to ensure OSUT trainees would understand the terms presented. For example, the reference to a "TOC" was replaced with "tent," and the phrase "cat-eyes" was replaced by the phrase "reflective tape." Other uses of Army acronyms or references to situations unfamiliar to OSUT trainees were either explained or deleted.

The Text condition differed from the Program condition as perceptual phenomena which can be experienced only when the eyes have dark adapted were not illustrated graphically. Thus, there were no graphics and illustrations of diamond viewing, autokinesis, the Purkinje shift, reduced visual acuity, and the effects of lights on dark adaptation. These phenomena were only described, not demonstrated. On the other hand, the normal blind spot could be demonstrated. The graphic associated with it was included in the Text condition.

Another difference between the two presentations was that the participants in the Text condition could clearly read the material in the hand-out. However, for those in the Program condition, both listening and observation skills were important. Because the unaided program is presented in the dark and the light level of the slides simulates the reduced visual acuity associated with twilight conditions, the word slides are not clear to the viewer. The trainees in the Program condition had to rely on the instructor to convey all the material, there being no guarantee that everyone could read the slides. As much of the technical information was presented on word slides and could not be demonstrated, those in the Program condition had to listen carefully to acquire much critical information.

The reading grade level of the text was 7.3 according to the Flesch-Kincaid formula. This formula is based on the number of words per sentence and the number of syllables per word. As the text was based on the "Possible Script" presented in the guide, it reflected the conversational characteristics of the guide as well. Short sentences were common, with an average of 14 words per sentence. The average number of syllables per word was 1.5.

For both conditions, the information on the "DEATH" slide was deleted. This slide consists of the letters "D," "E," "A," "T," and "H." The letters stand for drugs, exhaustion, alcohol, tobacco, and hypoglycemia. During Experiments A and B, this slide raised technical medical questions beyond the scope of the program. In addition, much information on this slide did not relate directly to night vision, but to factors that affect a soldier's overall ability to function at night. In the revised version, any information on unaided night vision unique to this slide was incorporated in other slides.

Procedure. Trainees were randomly assigned to the Program condition or to the Text condition. While those in the Program condition received the unaided program, those in the Text condition read the written material. Each group took the same written test immediately following completion of the program. Those in the Text condition were told they could study the material until they felt they were ready to take the test. A member of the research staff presented the unaided program, the same instructor as in Experiment A.

The trainees had just entered basic training. They had been in the Reception Station at Fort Benning for 10 days and were assigned to their training company the following day. Thus they had no prior Army training or experience in night operations.

Criterion measures. As in Experiments A and B, a written test of knowledge was administered following the unaided program. This posttest had 62 items (see Appendix F). The retention test, given 24 days later, had 47 items (see Appendix F).

Of the 50 items in the test used in Experiments A and B, 40 items were repeated in the posttest for the trainees; individual words in each of three items were replaced by a words familiar to trainees; one item was revised substantially; and six items were deleted. Thus 43 items on the posttest for Experiment C were considered equivalent to items in the test used throughout Experiments A and B. Items were deleted from the test used in Experiments A and B for a variety of reasons (e.g., redundancy with other items, content incorporated in new items, judged as too difficult for OSUT trainees with no night operations experience). Eighteen items were added to the posttest for the trainees. Of these 18, 14 constituted a series of true-false questions (see Appendix F, items 32a-g and 33a-g) covering the extent to which trainees knew when to use their peripheral versus their central vision at night.

Of the 47 items in the retention test, 35 items were identical to those in the posttest; two were edited slightly, resulting in 37 items which were equivalent on both tests. Ten other items were specific revisions of posttest items. Items were revised to prevent the post and retention tests from being identical. For example, in the posttest, trainees were asked which color was hardest to see at night. In the retention test, this item was revised; trainees were asked which color was easiest to see. The two series of true-false questions on peripheral and central vision were reduced to two multiple-choice items. Three other items on the posttest were deleted entirely from the retention test.

As in Experiments A and B, items were classified by importance, program presentation, and unaided topic. These classifications are presented in Appendix G. The major shift in emphasis from the posttest to the retention test was to reduce the proportion of application items in the retention test.

Across all the tests used in Experiments A, B, and C, 32 items were identical. Thirty-six items were considered equivalent, however, because the changes to four items were minor.

After the retention test, trainees were asked to indicate if they had talked to others about the unaided night vision instruction, and if so, the topics they had discussed.

Baseline group. In order to determine what OSUT trainees know about unaided night vision when they first enter the Army, a baseline measure of proficiency was obtained from a separate group of 30 OSUT trainees. These trainees, who were in the same stage of training as the trainees in the Text and Program groups, took the retention test without receiving any formal instruction on unaided night vision. After the test, they were asked about prior unaided night vision training; the same question asked of the soldiers in Experiments A and B.

Results

Background of the trainees. The average age of the trainees was 20.6 years (SD = 3.3), and most, 62%, had at least a high school diploma. The average general technical (GT) score from the Armed Services Vocational Aptitude Battery (ASVAB) was 107.1 (SD = 11.1). The GT score is a combination of verbal (word knowledge and paragraph comprehension) and arithmetic reasoning subtests from the ASVAB. No significant differences between the Program and Text groups occurred on these background variables (see Appendix I).

Posttest results. Table 7 shows the overall score, in terms of the percentage of items answered correctly. There was no significant difference between the experimental conditions, $F(1, 77) = 0.57$, $p < .45$ (see Appendix I; experimental condition and session were between-subjects factors in the ANOVA).

Table 7
Mean Percentage Correct on All Items on the Posttest - Experiment C

Trainee Grouping	Experimental Condition								
	Program			Text			Program and Text		
	M	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*
All Trainees	70	10	40	68	12	41	69	11	81
GT Categories									
< 100	71	9	9	60	8	12	65	10	21
100-109	65	10	15	63	8	16	64	9	31
110-119	66	9	7	78	7	7	72	10	14
> 119	78	6	9	83	6	6	80	6	15

However, the effects of the Program and Text conditions varied when the trainees' GT scores were considered. A correlational analysis showed that the relationship between GT score and total test score differed for the two experimental conditions (see Table I11). Although both correlations were significant, for the Program group, the correlation was .33 ($p < .05$), while for the Text group the correlation was higher, .72 ($p < .0001$). This was a significant difference, $z = 2.45$, $p < .01$. The GT score was then included as a factor in the ANOVA. Four GT categories were generated: scores less than 100, scores from 100 to 109, scores from 110 to 119, and scores 120 and greater. There was a main effect for GT category, $F(3, 73) = 14.33$, $p < .0001$, and a significant interaction between the experimental condition and GT category factors, $F(3, 73) = 6.23$, $p < .0008$ (see Table 7 for means). This interaction is illustrated in Figure 3; it is disordinal (Lubin, 1961). As expected, given the correlation of .72 for the Text group, as the GT score increased so did the total test score. However, for the Program group, the highest test scores were for the trainees with the highest as well as the lowest GT scores. In addition, trainees in the Program condition in the lowest GT category scored higher than the trainees in the same GT category in the Text condition. Yet, trainees in the Program group in the two highest GT categories scored lower than trainees in the same GT categories in the Text condition. Thus the 35-mm slide version of the unaided program benefited the trainees with the low GT scores more than the text version; the script version of the program was more effective for trainees with the high GT scores.

Item importance and presentation subscores were also examined with repeated measures ANOVAs, using the same analytic rationale applied to the data in Experiments A and B. Experimental condition and session were the between-subjects factors. No significant differences occurred between the two experimental conditions on these subscores (see Appendix I). However, there was a significant main effect for item importance, $F(1, 77) = 13.70$, $p < .0004$. Subscores on items covering the more important material were higher than those covering material designated as less important, $M = 71\%$, $SD = 12$ and $M = 65\%$, $SD = 14$ respectively. In addition, there was a significant effect for item presentation subscores,

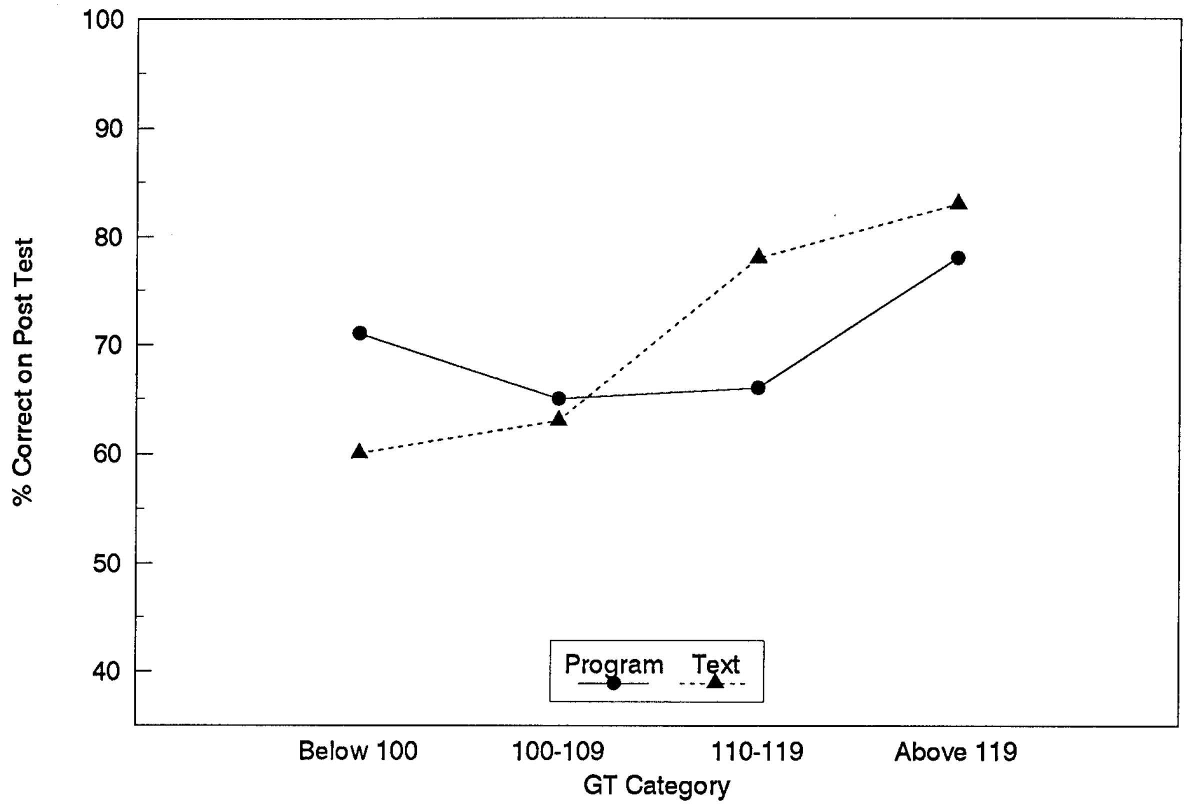


Figure 3. Interaction between experimental condition and GT category on the posttest in Experiment C.

$F(2, 154) = 9.99$, $p < .0001$. The demonstration subscores were highest ($M = 73\%$, $SD = 16$), the technical subscores next ($M = 70\%$, $SD = 15$), and the application subscores were the lowest ($M = 65\%$, $SD = 13$). Similar results occurred when GT was included as a factor in the ANOVA. The relationship between GT scores and the importance and presentation subscores was basically the same as that with the total score (see Table I11 in Appendix I).

Retention test results. Sixty-five of the original 81 trainees (80%) were retested; 30 from the Program condition and 35 from the Text condition. For both conditions, the trainees who were not retested had GT scores two to three points lower, were one to three years older, and were less likely to have a high school education than the trainees who were retested (see Table I2).

A repeated measures ANOVA was conducted on the posttest and retention test scores. Experimental condition and GT category were the between-subjects factors and time the within-subjects factor. The GT category was included in order to determine if the interaction between GT category and the Program and Text conditions remained on the retention test. The same ANOVA was repeated using the 37 items common to the posttest and retention test.

The total score decreased from the posttest to the retention test, from an average of 69% correct to 62% correct, $F(1, 57) = 49.19$, $p < .0001$. A strong linear relationship did continue between the GT and test scores for trainees in the Text condition, $r = .73$, $p < .0001$. As on the posttest, the relationship between GT and test scores for trainees in the Program condition was significant, $r = .50$, $p < .01$, and it was lower, but not significantly lower, than the Text correlation (Table I11).

On the total score, there was a main effect for GT category, $F(3, 57) = 17.88$, $p < .0001$. There was also a significant interaction between experimental condition and GT category, $F(3, 57) = 3.84$, $p < .0142$. This interaction on retention scores was essentially the same as the posttest interaction shown previously in Figure 3. The means are in Table 8; the interaction is illustrated in Figure I1. Overall, the positive effects of the Text condition continued for trainees with high GT scores, whereas the positive effects of the Program condition continued for trainees with low GT scores. The same effects occurred when items common to both tests were examined.

Table 8
Mean Percentage Correct for Trainees Who Took Both the Posttest and the Retention Test - Experiment C

Trainee Grouping	Posttest		Retention Test		Both Tests	
	Program *M* (*SD*)	Text *M* (*SD*)	Program *M* (*SD*)	Text *M* (*SD*)	Program *M* (*SD*)	Text *M* (*SD*)
All Test Items on Posttest and Retention Test						
All Trainees	70 (10)	68 (12)	64 (11)	60 (14)	67 (10)	64 (12)
GT Category						
< 100	71 (9)	60 (7)	62 (9)	54 (12)	67 (9)	57 (9)
100-109	63 (11)	63 (8)	57 (9)	53 (11)	60 (10)	58 (8)
110-119	69 (7)	78 (7)	64 (10)	69 (5)	67 (8)	73 (5)
> 119	77 (5)	84 (6)	73 (9)	82 (8)	75 (6)	83 (6)
Items Common to Posttest and Retention Test						
All Trainees	71 (12)	67 (14)	65 (11)	61 (15)	68 (11)	64 (14)
GT Category						
< 100	72 (10)	54 (7)	63 (9)	54 (12)	68 (9)	54 (9)
100-109	64 (15)	63 (10)	59 (11)	53 (12)	61 (12)	58 (10)
110-119	71 (10)	77 (8)	68 (12)	70 (5)	69 (11)	74 (6)
>119	79 (5)	88 (6)	71 (10)	83 (8)	76 (7)	86 (6)

The only significant effect involving item importance was a main effect for importance subscores when the common items were analyzed, $F(1, 57) = 14.93$, $p < .0001$. Subscores on the items testing the more important content were higher than subscores for the less important content, $M = 70\%$ correct ($SD = 16\%$) versus $M = 63\%$ correct ($SD = 13\%$).

On the program presentation subscores, two effects were significant when all, as well as just the common, items were analyzed. Program presentation interacted with experimental condition, $F(2, 114) = 3.74$, $p < .0268$ (all items). For the Program and Text conditions, application subscores were similar (65% and 66% respectively), while demonstration and technical subscores were higher for the Program than the Text condition (demonstration, 71% versus 64%; technical, 67% versus 64%, see Table H18). Program presentation also interacted with the time of testing, $F(2, 114) = 15.76$, $p < .0001$ (all items). Application subscores were similar across tests (65% and 66%), while demonstration and technical subscores decreased (demonstration, 74% to 61%; technical, 71% to 60%; Table H19).

Comparison with baseline group. The Baseline group's background was similar to the other trainees. There were no significant differences on the demographic variables for the two groups. The average age of the trainees in the Baseline group was 20.83 ($SD = 2.65$); 77% had at least a high school education; the average GT score was 110.10 ($SD = 12.55$). No more than 27% indicated prior training on any of the unaided night vision topics covered in the program. The correlation between GT score and total test score was .49, $p < .005$.

The Baseline group's average score on the retention test was 46% correct ($SD = 8\%$). This score was significantly lower than the Program and Text groups' score of 62% correct on the same test, $t(93) = 6.26$, $p < .0001$. Thus, although trainees in the Program and Text groups did forget some material over a period of three weeks, a substantial amount was retained. Scores did not decrease to the level of trainees who had no instruction on unaided night vision.

Discussion and Summary

Although differences between the Program and Text conditions were not necessarily expected on the posttest, they were expected on the retention test, particularly in light of the program's effectiveness with the more experienced soldiers in Experiments A and B. However, this was not the case. On the posttest, the two instructional techniques did not differ on total score or on the subscores. Overall, subscores on items which tested the more important concepts were higher than those testing less important concepts. Presentation subscores were highest on demonstration-related items and lowest on application items. Scores declined from the posttest to the retention test, from 67% correct to 64% correct, and the overall rate of decline was the same for both instructional techniques. Whereas, application subscores remained relatively constant from the posttest to the retention test, both the demonstration and technical subscores declined. The only significant effect for instructional technique occurred when both the post and retention tests were analyzed. The demonstration-related subscores were higher for the Program than the Text condition, technical subscores were slightly higher for the Program condition, and application subscores were the same.

These overall findings support Olson and Bruner's (1974) proposition that different instructional techniques do not necessarily result in differences in knowledge acquired. In retrospect, there was substantial overlap in the symbol systems used with the two techniques. Much information about night vision was conveyed via the linguistic system. In the Program condition this information was conveyed verbally, yet often reinforced with the iconic system via the demonstrations. The Text condition was all prose. All technical material was presented with linguistic symbol systems. In addition, the terms, phrases, and examples used in these two contexts were held constant as much as possible. The text was based on the program guide, and the instructor adhered to the guide very closely.

What is acquired during the unaided program beyond information on unaided night vision? An attempt was made to assess possible unique effects resulting from processing, organizing, understanding, and storing the images presented in the perceptual demonstrations. This approach was consistent with the proposition (Olson & Bruner, 1974; Salomon, 1979, 1971) that instructional media are distinguished not so much by the knowledge they convey, but by the skills used and developed while acquiring this knowledge from a particular medium. For example, in the Purkinje demonstration, trainees were told that red light can become dim and even disappear at night; they also experienced this. Trainees experienced the night blind spot and were told that objects can disappear if you stare at them. The program also provided an opportunity for individuals to explore how their eyes reacted to the demonstrations.

An analysis of scores on individual items was conducted as some test items were expected to discriminate the two groups. In retrospect, however, most test items did not focus on unique effects, because the phenomena demonstrated in the program were usually described similarly in the Program and the Text conditions. One item on the autokinetic illusion (#31) did examine information unique to the demonstrations in the Program condition. It asked in what direction the light moved in this illusion. Of the trainees in the Program condition, 75% answered correctly on the posttest; 83% on the retention test. In the Text condition, 46% answered correctly on the posttest; 43% on the retention test. However, this difference in scores could probably have been eliminated by simply telling trainees in the Text group that the light moves in different directions for different individuals.

So a fundamental question regarding whether the lecture-demonstration technique did, in fact, produce unique effects in the processing, storing, organizing, or understanding of unaided night vision concepts and principals as compared to the text version was not tested. Different criterion measures may be needed. Assessment techniques focusing on structural knowledge (Jonassen et al., 1993), free-recall, or the ability to explain critical concepts may be needed. Procedures used to assess structural knowledge may be more sensitive to the unique cognitive functions produced by the lecture-demonstration and text versions. Free recall measures may also be more sensitive to what is learned from the unaided program. Waddill, McDaniel, and Einstein (1988) found that pictures in prose improved free recall more than cued recall. Paivio (1971, p. 202) concluded that free recall performance is a function of concreteness, being higher for objects or pictures than for the words which designate such objects (e.g., a picture of a piano versus the word "piano").

Perhaps a longer retention interval, with either cued or free recall measures, would have produced differences. When retested, trainees were asked if they discussed the program with anyone, and if so, what they discussed. In the Program group, 63% indicated they had talked to someone else about the program, whereas only 37% did in the Text group. These results indicate a behavioral difference resulting from the two methods of instruction, but it did not impact test scores.

The unexpected finding, which contributed to the lack of a program effect, was that the trainee's GT score interacted with the Program and Text conditions. This interaction, generally referred to as a trait-treatment interaction (Berliner & Cahen, 1973) or aptitude-treatment interaction (Corno & Snow; 1986, Snow, 1977), occurred on both the posttest and the retention test. Those with high GT scores benefited the most from the Text condition; those with low GT scores, from the Program condition. It was assumed that the GT score on the ASVAB can be considered a measure of general ability, given that it is a composite of verbal and math tests.

In reviewing the research on aptitude-treatment interactions involving general ability, Snow (1977) indicated the general hypothesis was that:

> instructional treatments differ in the information-processing burdens they place on, or remove from, the responsibility of the learner, and the regressional slopes of cognitive outcomes on G [general ability] become steeper or shallower accordingly. It seems that as learners are required to puzzle things out for themselves, to organize their own and build their own comprehension, the more able learners can capitalize on their strengths profitably. As instructional treatments are arranged to relieve learners from difficult reading, analyzing complex concepts, and building their own cognitive structures, such treatments seem to compensate for, or circumvent, less able learners' weaknesses and to reduce the regression slope on G. These latter treatments thus help Low G students; the High G students may or may not do well in them. Often the impression from such studies is that High G students can do well enough, no matter what treatment is applied (p. 69).

However, Snow suggested that High G students may not always do well regardless of instructional treatment, in particular when simplified demonstrations, models, or simulations are part of the instruction.

Salomon (1979) argued that "one symbol system, when compared with another, can present information in better correspondence to --- or congruity with --- the mode of internal representation that an individual with a given cognitive make-up and task can best utilize. The closer the correspondence, or isomorphism, the easier it is for the learner" (p. 73). The example was given of college students who had to depict how to get from one building to another. Half drew a map; half wrote directions. Then a random half of each group was given either a map or verbal description of an imaginary island. When tested on their knowledge of the island, these four groups did not differ in the correctness of their responses but did on time to complete the test. Students, who were graphically inclined and were given the map, and those who were verbally inclined and given the verbal description, completed the test the fastest. The inference was that these two groups needed less time to process and transform the new information as there was greater correspondence between their internal mode of representing information and the external information they encountered.

Thus, it may be that the Program condition benefited the trainees with the low GT scores because it compensated for their more limited verbal and reading skills and was also in modes, auditory and perceptual, which corresponded more closely to their strengths. Those with low GT scores in the Text condition had to work with written material, which they may have found difficult. On the other hand, the Text condition may have benefited the trainees with the high GT scores because it corresponded to their verbal and reading strengths, whereas the Program condition forced them to rely on auditory and perceptual modes of learning, requiring more effort to process the information. In addition, their reading skills were hampered in the Program condition since the word slides were difficult to read (20/50 visual acuity). The results support Snow's (1971) suggestion that "high G" individuals do not necessarily do well under all modes of instruction.

That trainees reacted differently to the instructional media is supported by their written comments after completing the posttest. Trainees were asked what they would tell someone else about the program. Trainees in the Text condition commented on reading the material, e.g., "just to read carefully (GT score = 115)," "read it carefully, because it has a lot of helpful information (GT = 105)," "you could learn a lot by just reading the information (GT = 103)," "basically to read everything very carefully and try to remember the main points that were said throughout the booklet (GT = 123); "I would tell them they should read this text. It was simple to read and easy to understand (GT = 126)," "I don't know because I have to learn more about it. I have a learning disability, so I'm not as smart (GT = 89)," "It may, however, be a bit too technical for some readers (GT = 125)." All soldiers recognized the importance of reading the material carefully. Apparently, trainees with the higher GT scores did not find the material difficult, but recognized that others might. Two trainees (GT = 102 and 110) indicated that demonstrations would add to the instruction.

On the other hand, trainees in the Program condition commented on listening to the program and experiencing the demonstrations, e.g., "Listen, it's good (GT = 91)," "It is good, they should see it (GT = 99)," "To listen and learn. It can help (GT = 95)," "It was a good experience and I've learned a lot from it (GT = 111)," "It might give them a headache from eye strain (GT = 129)." The last comment was from a trainee with a high GT score. It may reflect some frustration in attempting to read the slides, which were not always clear.

To maximize learning when such interactions occur, more than one instructional treatment may be needed. It has been suggested that the instructional technique which corresponds to the learner's strength(s), that avoids the learner's weaknesses, be presented first (Snow, 1971).

Lastly, Baseline group comparisons showed that both the Program and Text conditions had positive effects. The posttest scores were 1.5 times greater than the Baseline scores, and the retention scores were 1.3 times greater. The relative effects of the unaided instructional program on both the post and retention scores were very similar to those found by Clark et al. (1945).

Responses to individual items showed that the Baseline group's knowledge of unaided vision shared the same weaknesses evidenced on the initial test for the No Program group in Experiments A and B. In addition, the trainees knew less about dark adaptation, the night blind spot, and colors at night. For example, 85% said it took five minutes or less to completely dark adapt. The impact of light on dark adaptation was not well understood, e.g., the effect of covering one eye when exposed to a light, which light sources have the strongest impact on dark adaptation. Responses to several items indicated many were unaware of the night blind spot.

Conclusions

Although formal instruction on unaided night vision has been an integral part of Army ground force training in the past, this training did not exist when the research was conducted. In addition, the current doctrine and training literature for ground forces, published from 1984 to 1992, contained little information on unaided night vision. Consequently, it was not surprising to find soldiers reporting little training in this area, soldiers with limited and fragmentary knowledge of unaided night vision, and instances where this lack of knowledge resulted in poor decisions regarding night operations. The experiments with experienced soldiers showed that their initial knowledge of this domain was the same regardless of years served in the Army; they answered about half the items correctly.

In all three experiments, the unaided night vision program substantially increased experienced soldiers' and trainees' knowledge. The same results occurred for experienced soldiers regardless of whether the instructor was a member of the research staff and or a military instructor. Findings also showed that the material was not immediately forgotten. Scores on items testing the more important content were consistently higher than scores on items testing less important content. For experienced soldiers, the program had a greater impact on their knowledge of demonstration-related information and the more technical material than on their ability to apply unaided night vision principles and concepts.

The box plots in Figure 4 compare the groups in all experiments on the items common to all tests. Scores increase steadily as a function of taking the program and with Army experience. The lowest performing group was the OSUT Baseline group (Group I), trainees with no Army night operations experience and no exposure to unaided night vision instruction. Scores were highest for the JRTC O/Cs (Group VII). They had received the program, had been in the Army the longest, and had the most experience in night operations given their role at JRTC. Their scores were 1.8 times higher than those for the trainee Baseline group.

Estimates of the relative contributions of Army experience and training and the unaided program were obtained by comparing the median scores for various groups. The unaided program increased scores 1.3 times for experienced soldiers (Group V vs Group II) and 1.5 times for the trainees (Group IV vs Group I). Several estimates were made of the contribution of Army experience. A comparison of Group II with Group I provided the most direct estimate as neither group had the unaided program; scores increased 1.2 times. Other estimates were obtained by comparing the soldier to trainee groups who had the program. Scores increased 1.02 times when

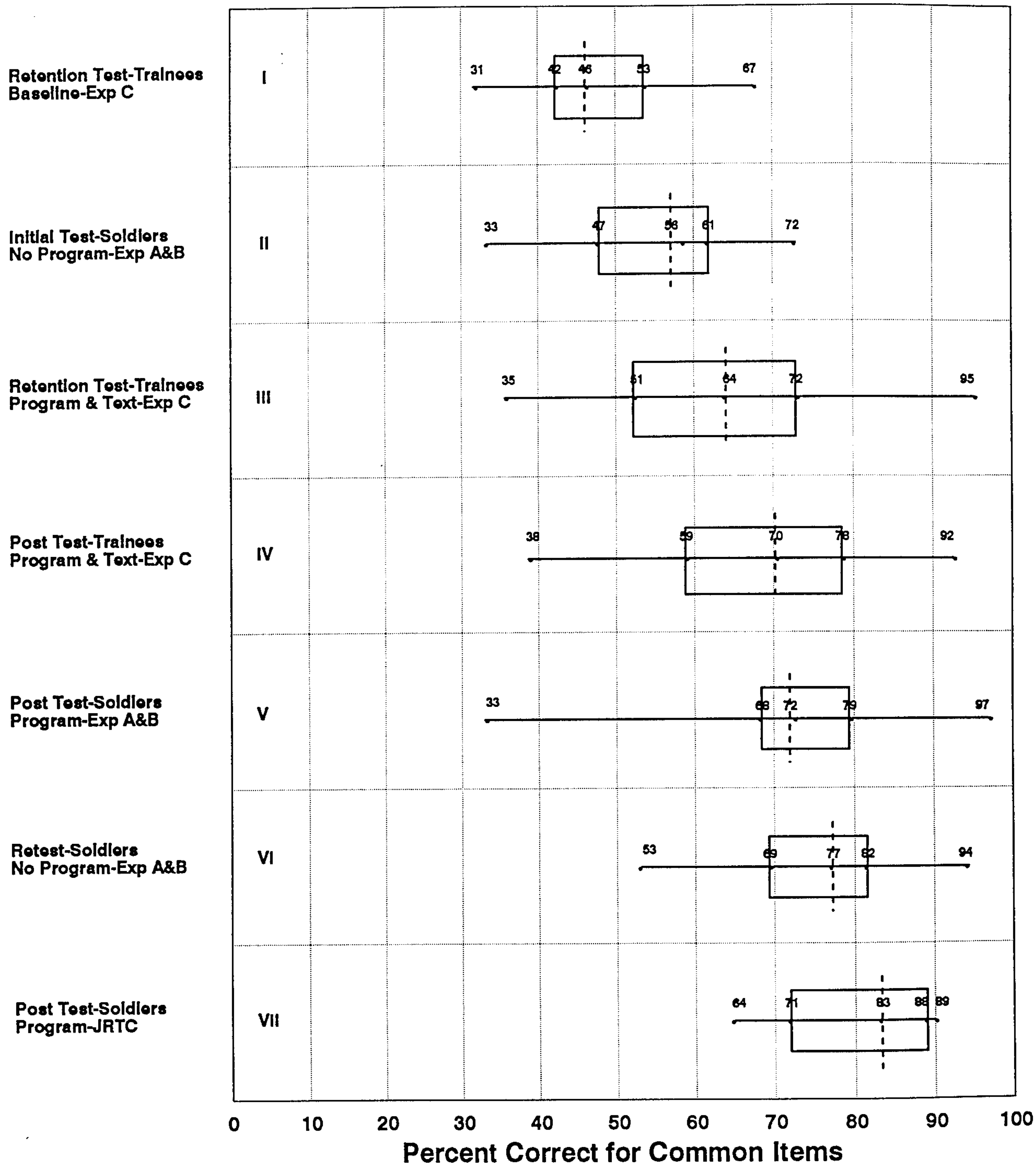


Figure 4. Box plots on common test items for each experimental condition. (The medians in the figure are within two percentage points of the means.)

comparing Group V with Group IV; they increased 1.2 times when comparing Group VII with Group IV.

The spread of scores, as reflected in the interquartile range and the range, was the least for the extreme groups (I, II, VI and VII). In essence, the spread was least for those who knew the most and those who knew the least. In addition, no individual achieved a score close to the maximum of 100% in either "baseline" group (I and II). High scores occurred only after instruction.

The experiment with Infantry trainees showed that, although the 35-mm program is effective, its overall effectiveness was equivalent to reading a text version of the same material. This finding is consistent with the general proposition that no instructional medium is inherently better than another (Olson & Bruner, 1974; Salomon, 1979). However, the impact of these two instructional techniques varied with the aptitude of the trainee. The text version was better for trainees with high GT scores; the 35-mm slide presentation, better for trainees with low GT scores. This trait-treatment interaction occurred immediately after training and about a month later as well.

It has been argued (Salomon, 1979; Snow, 1977) that instructional techniques whose symbol systems correspond to the learners' particular strengths, which compensate for learner weaknesses, make learning easier. Therefore, it may be that the Program condition benefited the trainees with the low GT scores because the auditory and perceptual aspects of the program compensated for their more limited reading skills. Those trainees with low GT scores in the Text condition had to work with written material, which they may have found difficult. On the other hand, the Text condition may have benefited the trainees with the high GT scores because it required verbal skills, whereas the Program condition forced them to rely on auditory and perceptual modes of learning, requiring more effort to process the information. In addition, their reading skills were hampered in the Program condition since many of the word slides were difficult to read under low illumination. From a practical point of view, these results suggest that both the 35-mm version and a printed version of the information may be needed to maximize learning.

Additional measures may be needed to assess thoroughly the effects of instruction in unaided night vision. What are the unique effects of the lecture-demonstration format when it is tailored to demonstrate perceptual phenomena? Of what value are the redundant, yet different, representations provided by the perceptual illustrations and verbal descriptions? In what ways does this type of program build upon experience gained in night operations exercises? Assessment procedures which incorporate measures of structural knowledge, free-recall, the ability to explain critical concepts, or longer retention periods may be needed to obtain a more complete picture of proficiency in this domain.

The unaided program focuses on what is known as declarative knowledge as opposed to procedural knowledge (knowing "how to"). This declarative knowledge is a prerequisite to procedural skill development. A clear advantage of the program is that the knowledge acquired can be applied immediately, without practice, by both leaders and soldiers, and positively impact night operations. For instance, unit policies can be established on the use of sunglasses during the day and on other means of protecting dark adaptation before night operations, on the type of lights to use as signals or in an enclosed area, and on maintaining light discipline at night. Soldiers can easily close one eye when suddenly exposed to a bright light. Training soldiers to use diamond viewing habitually under stress and fatigue or to estimate distance under different levels of illumination would probably require a different training program. Prior research (Sharp et al., 1952; Taylor, 1960) suggests this is the case.

The experiments were also used to improve the prototype program. The instructional features of the guide and the slides were enhanced; ground force examples were added; examples unique to aviators were deleted. The final guide is provided in a separate report by Dyer and Mittelman (1995). Although extensive research on night vision was conducted in the 1930s through the 1950s, some questions related to ground force operations remain. The distances at which the special signalling and marking devices (e.g., different colored standard and mini chem lights, colored strobes) used by today's infantry units and other ground forces can be seen, the effects of the night vision goggles on unaided night vision, and the ability to estimate range at night all need to be investigated further. Future findings on these issues should be incorporated in the program.

In summary, the research findings have several implications for future research and Army practice. They showed the need for further research on how soldiers understand and process perceptual phenomena, and how training in this area is best accomplished. The need to provide formal instruction in technical areas was demonstrated, as night operations experience or "on-the-job-training" resulted in limited and fraqmentary knowledge about unaided night vision. Finally, the experiments showed that upon implementation of the unaided program, commanders should expect about a 40% increase in soldier knowledge regardless of prior experience; knowledge and information which can be applied directly to improve soldier performance and to refine unit standing operating procedures for night operations.

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APPENDIX A

FRONT-END ANALYSIS OF UNAIDED NIGHT VISION TRAINING REQUIREMENTS FOR GROUND FORCES

Knowledge Requirements

Anatomy of the Eye

Parts of the eye and their relationship to night vision
- Cornea
- Iris
- Pupil
- Lens
- Retina
- Rods and cones
- Optic nerve

The Dark Adaptation Process

Time required to dark adapt [30 to 45 minutes]
Dark adaptation curve [its shape and reason for shape]
Increased sensitivity of eyes when dark adapted [100,000 times more sensitive]
Individual differences exist in the rate of dark adaptation; reasons for individual differences
What happens in the eye during dark adaptation - increase in visual purple (rhodopsin)
- Composition and location of visual purple
- How visual purple reacts to light
- How visual purple reacts to darkness
- Implications of visual purple characteristics for night operations

Three Types of Vision

Photopic vision (called daylight in program)
Mesopic vision (called twilight in program)
Scotopic vision (called night in program)

Know the following about each type of vision
- When each type of vision occurs
- Part(s) of eye responsible
- Ability to see detail; degree of visual acuity with each type
- Ability to see colors
- Depth perception
- Reaction time

The Night or Central Blind Spot

Definition of the night blind spot
Consequences of the night blind spot [objects disappear or fade away; larger objects missed as distance increases]
How to overcome the night blind spot
    Scanning techniques (off-center viewing, diamond viewing)
    Factors inhibiting scanning at night

The Normal or Physiological Blind Spot

Definition of the normal blind spot
Consequences of the normal blind spot
How to overcome the normal blind spot

Color Vision

Receptors in the eye responsible for color vision
How the ability to see colors changes as illumination decreases
    Role of rods and cones
    Purkinje shift (differential sensitivity of rods and cones to different wavelengths of light - rods not sensitive to long wavelengths such as red, but sensitive to short wavelengths such as blue and green; cones less sensitive to short wavelengths, more sensitive to long)
    Best procedure to determine the color of a light source
Field applications of principles of color vision at night
    Distances at which different light sources (white and colored) can be seen and the implications of this for tactical operations (e.g., use of filters in flashlights, maintenance of light discipline, protect dark adaptation, which colors of light are likely to be detected over a long distance; when colored lights should be replaced by another marking or signalling technique)
    Why Pathfinders often use light patterns for marking rather than colors
    Ability to see colored smoke
    Ability to see different colored landmarks
    Why red markings are not visible under red light; why maps should be red-light readable

Protecting Dark Adaptation Before Night Operations

Amount of exposure to sunlight; effects of sunlight on visual purple
Effects of smoking; effect of hypoxia on dark adaptation
Effects of diet
    Levels of Vitamin A
    What foods contain Vitamin A
    Relationship of Vitamin A to visual purple

Use of dim lighting
Use of red lighting and/or goggles

Protecting Dark Adaptation During Night Operations

Effects of different types of lights (e.g., short bursts of light versus a flood light) on dark adaptation
Effects of length of direct exposure to light on dark adaptation; recovery times
How to control exposure to lights
- Minimize bright lights
- Avoid looking at lights
- Use of red light
- Close one eye

Effects of night vision goggles on dark adaptation

Visual Illusions

Autokinetic effect or autokinesis
- Definition
- Why and when the illusion occurs
- Consequences of the illusion
- How the illusion can be overcome

Purkinje shift
- Definition
- Why it occurs
- Consequences of the illusion

Other Factors Which Will Maximize Unaided Vision at Night

Scanning techniques to employ
Role of silhouette recognition due to reduced visual acuity
Use of prescription lenses/glasses to enhance vision

Skill Requirements

Skill in using scanning techniques which minimize the effects of the night blind spot (e.g., diamond viewing)

Use of techniques which protect dark adaptation when exposed to lights (e.g., close one eye, look away from bright sources, plan for use of dim or red light)

Scanning techniques which minimize the autokinetic effect

Ability to select appropriate marking and/or signalling devices

Target detection skills

Silhouette recognition skills

Range estimation skills

Ability to integrate principles of unaided night vision in unit standing operating procedures

APPENDIX B

UNAIDED NIGHT VISION IN THE ARMY'S TRAINING AND DOCTRINE MANUALS: HISTORICAL COMPARISONS (1950-1992)

Individual Skills Manuals

Current Manual
FM 21-75. (1984). *Combat Skills of the Soldier*
Preceding Manuals
FM 21-75. (1967). *Combat Training of the Individual Soldier and Patrolling*
FM 21-75. (1950). *Combat Training of the Individual Soldier and Patrolling*

Individual Skills Manuals Summary of Contents	FM 21-75		
	1950	1967	1984
Anatomy/Physiology of the Eye			
• Describes parts of the eye (lens, iris, retina, rods, cones, visual purple, pupil).	X	X	---
• Role of cones and rods in day and night vision described.	X	X	---
• Describes how the eye is similar to a camera.	X	X	---
Dark Adaptation in General			
• Takes about 30 minutes to dark adapt.	X	X	X
• Short cut method (stay in red-lighted area or wear red goggles for first 20 min followed by 10 min in darkness)	X	X	X
• Older people take more time to dark adapt.	X	---	---
Dark Adaptation and Lights			
• Night vision is quickly destroyed if light enters eye.	X	X	---
• Close or cover one eye to preserve adaptation if lighted areas cannot be avoided.	X	X	---
Protecting Dark Adaptation before Night Operations			
• Visual purple is chemically related to Vitamin A	X	X	---
• Lack of Vitamin A impairs night vision.	X	X	---
• Excessive amounts of Vitamin A will not improve night vision.	X	X	---
• Colds, headache, fatigue, narcotics, heavy smoking, and excessive use of alcohol reduce ability to see at night.	X	X	---
• Exposure to bright light for extended periods of time impairs both day and night vision.	---	X	---

Individual Skills Manuals Summary of Contents	FM 21-75		
	1950	1967	1984
Viewing Techniques			
• Off-center vision:			
1. Is the technique of keeping attention focused on object without looking directly at it.	---	X	X
2. When looking directly at an object, image is formed on the cone region which is not sensitive at night.	---	X	X
3. Look slightly to the left, right, above, or below the object, out of the corner of your eye.	X	X	---
4. The image is formed on the area of the retina containing rod cells, which are sensitive in darkness.	X	X	---
5. The most sensitive area varies in individuals, but is approximately 6 to 10° away from an object.	X	X	---
• Scanning			
1. Involves using off-center vision to observe an area or object.	X	X	---
2. When you use rod vision, the visual purple in rod cells is bleached out in 4 to 10 sec, and the object disappears[a].	X	X	---
3. Shift eyes so fresh rod cells are used.	---	X	---
4. Move eyes in short, abrupt, irregular movements over and around the target.	X	X	X
5. Concentrate your attention on the target, but do not look directly at it.	---	X	X
6. Pause a few seconds at each point.	---	X	X
7. Scan in a circular motion around the object of interest.	X	---	---
Seeing Objects at Night			
• Avoid sky-lining	X	---	---
• Light of a match can be seen up to 10 miles away.	X	---	---
Color Perception and Visual Acuity			
• In darkness, objects are faint and have no sharp outlines and little to no color.	---	X	---
• You must develop confidence to believe what your eyes tell you at night.	X	X	---

Individual Skills Manuals Summary of Contents	FM 21-75		
	1950	1967	1984
Exercises for Training in Night Vision			
• Equipment and Conduct			
1. Includes information on how to design and use the shadowgraph for indoor training.	X	X	---
2. For outdoor training, use natural terrain features, man-made objects and individuals.	X	X	---
• Training			
1. Can be conducted indoors or outdoors; indoor training should be conducted first.	X	X	---
2. If done outdoors, lighting should be equal to that of a brilliant half moon.	X	X	---
• Exercises			
1. Indoors			
a. Done in darkened room. Night vision is explained and shadowgraph is turned on.	X	X	---
b. Instructor stresses the varying rates of dark adaptation among students. Off-center vision and scanning techniques are practiced by viewing the corners of the screen.	X	X	---
c. After all have dark adapted, red lights are turned on to demonstrate their effect on dark adaptation.	X	X	---
d. Color spectrum is pointed out.	---	X	---
e. Practice maintaining dark adaptation by covering one eye when white light is turned on.	---	X	---
f. Includes demonstration that red colors cannot be seen readily under red light.	---	X	---
g. Wear goggles with red lens to demonstrate dark adaptation is retained with goggles.	X	---	---
2. Outdoors			
a. Same procedures as indoors, but available terrain features, man-made objects, and individuals are used.	X	X	---
b. Binoculars are used to point out improved vision over naked eye.	X	X	---

[a] Reason given for object disappearing is incorrect. The visual purple in the rod cells can be bleached out only when looking at lights, thereby reducing the level of dark adaptation. The correct reason for objects disappearing is that the night blind spot comes into play when looking directly at an object. Only central vision is used; therefore, the rods are not involved.

Infantry Platoon and Squad Manuals

Current Manuals
FM 7-8. (1992). *Infantry Rifle Platoon and Squad*
FM 7-92. (1992). *The Infantry Recon Platoon and Squad*
Preceding Manuals
TC 7-1. (1976). *The Rifle Squads: Mechanized and Light Infantry*
FM 7-8. (1980). *The Infantry Platoon and Squad (Infantry, Airborne, Assault, Ranger)*
FM 7-70. (1986). *Light Infantry Platoon/Squad*
FC 90-1. (1985). *Night Operations*

Infantry Platoon and Squad Manuals Summary of Contents	TC 7-1 1976 FM 7-8 1980	FC 90-1 1985	FM 7-70 1986	FM 7-8 and FM 7-92 1992
Anatomy/Physiology of the Eye				
• Cites the rods as the cells which provide night vision.	---	---	X	---
• Diagram of the eye with rods and cones identified.	---	---	X	---
Dark Adaptation in General				
• Soldiers adapt to darkness at varying degrees and rates.	---	X	X	X
• During the first 30 min, the eye sensitivity increases 10,000 times, but not much after that. [a]	---	X	X	X
• The lower the illumination level prior to darkness, the more rapid the dark adaptation.	---	X	---	---
Night Blind Spot				
• Central vision becomes less effective at night and a 5 to 10° wide blind spot develops.	---	X	---	---
• Central field of vision is superimposed to give binocular vision, and an object viewed using central vision may not be detected due to this blind spot.	---	X	---	---
• With the night blind spot, larger and larger objects will be missed as the distance increases.	---	X	---	---

Infantry Platoon and Squad Manuals Summary of Contents	TC 7-1 1976 FM 7-8 1980	FC 90-1 1985	FM 7-70 1986	FM 7-8 and FM 7-92 1992
Protecting Dark Adaptation Before Night Operations				
• Exposure to intense sunlight for 2 to 5 hrs causes a decrease in visual sensitivity which can persist up to 5 hrs. This can be intensified by reflective surfaces such as sand or snow.	---	X	X	---
• The effects of exposure to sunlight are cumulative and may persist for several days. Military neutral density (N-15) sunglasses or equivalent filter lenses should be used in bright sunlight when night operations are anticipated.	X (TC 7-1)	X	X	---
• Failure to eat foods that provide Vitamin A for prolonged periods can impair night vision. Too much Vitamin A will not improve vision; can be harmful.	---	X	---	---
• Use of alcohol, tobacco, and other drugs can impair night vision.	---	X	---	---
• Being physically fit enables the body to use oxygen more efficiently, thus enhancing night vision.	---	X	---	---

Infantry Platoon and Squad Manuals Summary of Contents	TC 7-1 1976 FM 7-8 1980	FC 90-1 1985	FM 7-70 1986	FM 7-8 and FM 7-92 1992
Dark Adaptation and Lights				
• Exposure to bright lights (such as flashlights, matches, flares or vehicle headlights) has an adverse effect on dark adaptation. Full recovery can take up to 45 min.	---	X	X	X
• Intensity and duration of exposure to light affect the degree to which dark adaptation is impaired. Brief flashes of light have minimal effects.	---	X	---	---
• Using night vision goggles impedes adaptation. If a soldier dark adapts before putting them on, dark adaptation is regained within 2 min after removal. [b]	---	X	X	X
• A unit that is inserted by parachute must dark adapt 20 to 30 min before exiting aircraft.	---	---	---	X (FM7-92)

Infantry Platoon and Squad Manuals Summary of Contents	TC 7-1 1976 FM 7-8 1980	FC 90-1 1985	FM 7-70 1986	FM 7-8 and FM 7-92 1992
Viewing Techniques				
• Scanning				
1. Enables soldiers to overcome many of the night vision physiological limitations of their eyes and reduces visual illusions.	---	X	X	X
2. Scan from right to left or left to right using slow, regular movement.	---	X	X	X
3. Avoid looking directly at a faintly visible object when trying to confirm its presence.	---	X	X	X
• Off-center vision				
1. Due to the night blind spot, viewing an object with central vision is ineffective.	---	X	X	X
2. Look 10° above, below, or to either side of an object rather than directly at it; allow peripheral vision to maintain contact with the object.	---	X	X	X
• Countering the bleach out effect				
1. If an image is viewed longer than 2 or 3 sec, it tends to bleach out. Avoid looking at an object longer than 2 or 3 sec to avoid this effect.	---	X	X	X
2. Shift eyes from one off-center point to another to keep object in peripheral vision.	---	X	X	X
• Shape of silhouette				
Since visual sharpness is reduced at night, soldiers must recognize objects by shape or silhouette. Knowing the architectural design of structures common to an area helps determine success with scanning techniques.	---	X	X	X

Infantry Platoon and Squad Manuals Summary of Contents	TC 7-1 1976 FM 7-8 1980	FC 90-1 1985	FM 7-70 1986	FM 7-8 and FM 7-92 1992
Color Perception and Visual Acuity • Color perception decreases at night. One can distinguish light and dark colors depending on intensity of reflected light	---	X	X	X
Visual Acuity • Visual sharpness is reduced. It is 1/7 of what it is during the day and only large, bulky objects can be seen.	---	X	X	X
• Object identification at night is based on generalized contours and outlines.	---	X	X	X
Depth Perception • Depth perception is affected	---	X	X	X
Distances at which Light Sources can be Seen on the Ground • Vehicle headlights, muzzle flashes from small arms and single cannons, bonfire, flashlight, lighted cigarettes and matches are cited.	---	---	X	---
Visual Illusions/Perceptual Effects • Autokinetic effect, mistaking ground lights for stars, relative motion, fixation, structural illusions, and size-distance illusion are explained.	---	X	---	---

Infantry Platoon and Squad Manuals Summary of Contents	TC 7-1 1976 FM 7-8 1980	FC 90-1 1985	FM 7-70 1986	FM 7-8 and FM 7-92 1992
Night Operation Tips and Techniques related to Unaided Night Vision				Only in FM 7-8
• Land navigation - Mark routes: identify vehicles, guards, and turning points; orient on unusual terrain features or man-made structures; use tracers to delineate boundaries and direction; celestial navigation.	---	X	X	X
• Target engagement - Improve by use of illumination.	---	X	X	---
• Fire Support - Mark target reference points.	---	X	X	---
• Equipment - Use of lensatic compass.	---	X	X	X
• Security - Stated that blue light is much more difficult to see at night than red light. Unlike red light, however, it does not hamper night vision. [c]	---	X	X	X
• Combat service support - Mark main supply route and logistic release points.	---	X	X	X
• Training - Suggestions for training night skills during the day.	---	X	---	---

[a] With full dark adaptation, after 30 to 45 minutes, the sensitivity of the eye is increased 100,000 times (Boff & Lincoln, 1988).
[b] The 2-minute time to regain dark adaptation after removal of night vision goggles stated in the manuals was based on research where individuals wore goggles (AN/PVS-5) for only five minutes. The time required to dark adapt after wearing goggles for a longer period of time, such as 2 or 4 hours, has not been investigated yet, but is most likely greater than 2 minutes.
[c] The information on colors in this section of the manuals is exactly the opposite of what is the case. Red light is more difficult to see at night than blue light, and red light does not hamper night vision.

Current Manual
FM 23-9. 1986. *M16A1 and M16A2 Rifle Marksmanship*

Marksmanship Manuals Summary of Contents	FM 23-9 1986
Dark Adaptation in General	
• Takes about 30 minutes to dark adapt.	X
• Maximum level reached in about 30 minutes[a].	X
Dark Adaptation and Lights	
• Eye must adapt again if light is encountered.	X
• Night vision degraded by fire on end of a cigarette and by red -lensed flashlight[b]; larger light sources cause more severe losses.	X
• Dark adaptation lost when artificial illumination is used. Artificial illumination allows use of iron sights.	X
Viewing Techniques	
• Focusing directly on an object at night results in it being visible for only a few seconds; then it becomes almost invisible.	X
• Must shift gaze slightly to one side of an object to see it. This allows the parts of the eye which are sensitive at night to be used. This is called off-center vision.	X
• If firing without artificial illumination, must use off-center vision to keep the target in sight. Use both eyes, look over the iron sights, and focus down range. Tracer ammunition may provide feedback on bullet trajectory.	X
Maintaining Dark Adaptation during Night Operations and Firing	
• Can close both eyes during artificial illumination to preserve night vision, but the soldier is ineffective during this period of time.	X
• Can close one eye to preserve night vision, but this results in an altered sense of perception which both eyes are then opened.	X
• Tactical considerations are the deciding factor regarding which technique to use.	X

[a] The dark adaptation process continues after 30 minutes.
[b] Red-lensed flashlight will not degrade dark adaptation or night vision.

Army Aviation Manuals

Current Manuals

FM 1-301. (1987). *Aeromedical training for flight personnel*

TC 1-204. (1988). *Night flight: Techniques and procedures*

Army Aviation Manuals Summary of Contents	FM 1-301 1987	TC 1-204 1988
Anatomy/Physiology of the Eye		
• Describes the cornea, pupil, iris, lens, retina, fovea, rods, cones, optic nerve, day blind spot, and visual purple (rhodopsin). Describes role of cones and rods in day and night vision.	X	X
• Describes how the eye is similar to a camera.	---	X
Light Levels		
• Describes the following: illumination, luminance, reflectance, contrast.	---	X
• Provides table showing common light sources and their amount of luminance.	---	X
Types of Vision		
• Describes photopic, mesopic, and scotopic vision, and the consequences of these types of vision for visual acuity and color perception.	X	X
• Color - at night is decreased or lost. Sensitivity of rods and cones varies with different waves lengths of light, with rods more sensitive to blue end of the spectrum than the red end.	X	X
• Detail - fine detail is impossible at night. Acuity is 1/7 of day vision under full moonlight, worse under less light.	X	X
• Retinal sensitivity - the central part is not sensitive at night, creating a night blind spot.	X	X
• Makes distinction between night and day blind spot.	X	X
• Discusses the night blind spot and its effects (e.g., as distance increases, larger and larger objects will be missed because of the night blind spot).	X	X

Army Aviation Manuals Summary of Contents	FM 1-301 1987	TC 1-204 1988
Dark Adaptation		
• The degree of dark adaptation increases as the amount of visual purple in the rods increases. People dark adapt at different degrees and rates.	X	X
• During first 30 min, eye sensitivity increases 10,000 times; very little increase occurs after this time.[a]	X	X
• Dark adaptation takes about 30 - 45 min to approach maximum level. The lower the starting level of illumination, the more rapid complete dark adaptation is achieved.	X	X
• Exposure to bright light has adverse effect on dark adaptation. Degree of impairment and the time to regain full dark adaptation depends on intensity and duration of exposure.	X	X
• Exposure to bright sunlight has cumulative effect on dark adaptation. Reflective surfaces, such as sand or snow, or water, intensify this condition. Exposure to sunlight for 2 to 5 hrs can decrease sensitivity for up to 5 hrs.	X	X
• Lack of oxygen to bodily tissues (hypoxia) will reduce the sensitivity of the rod cells.	X	---
• Night vision devices affect dark adaptation. If previously dark-adapted, can regain night vision within 2 or 3 min.[b] Vision with image intensification devices is photopic, but the low light levels do not fully bleach out the rhodopsin (visual purple).	---	X
Visual Problems which can affect Night Vision		
• Presbyopia: hardening of the lens, lose ability to focus on nearby objects with age, particularly under red illumination.	---	X
• Night myopia: Myopic individuals can experience blurred vision when viewing blue-green light. Need to wear glasses if have mild refractive errors. The resting point of the eye may make it more myopic (dark focus).	---	X
• Astigmatism: irregularity of the shape of the cornea that may cause an out-of-focus condition.	---	X

Army Aviation Manuals Summary of Contents	FM 1-301 1987	TC 1-204 1988
Protecting Dark Adaptation before and during Night Operations		
• When exposed to bright sunlight, aviators should wear military neutral density (N-15) sunglasses or equivalent filter lenses, especially when they anticipate unaided night flight.	X	X
• Instrument and airfield lighting should be adjusted to the lowest possible level.	X	X
• Red cockpit or instrument lighting should be used; blue-green lighting may also be used at low intensities. Discusses pros and cons of colors for cockpit lighting.	X	---
• Exterior lights should be turned off or taped.	X	---
• Aviators should wear approved red-lens goggles or use red lighting before executing night flying operations; allows dark adaptation to begin.	X	---
• Pilots should turn aircraft away from high-intensity light sources or select alternate route if concentrations of light are expected.	X	X
• The time during which ordnance is expected should be limited. When firing automatic weapons, use short burst of fire. Covering one eye or looking away from firing will minimize the loss of dark adaptation.	X	X
• Supplemental oxygen should be used at 4,000 ft.	X	X

Army Aviation Manuals Summary of Contents	FM 1-301 1987	TC 1-204 1988
Viewing Techniques		
• Off-center viewing		
1. Look 10° above, below, or to either side of an object rather than directly at it to compensate for the night blind spot.	X	X
2. An object viewed longer than 2 or 3 sec will begin to bleach out and become one solid tone. Shift eyes from one off-center point to another to keep the object in the periphery.	X	X
• Scanning		
1. To scan effectively, aviators should look from right to left or from left to right and begin scanning at the greatest distance an object can be perceived (top) and move inward toward the position of the aircraft (bottom). Use a stop-turn-stop-turn motion.	X	X
2. An area approximately 30° wide should be scanned. This viewing angle will include an area approximately 250 m wide at a distance of 500 m.	X	X
3. When moving from one viewing point to the next, aviators should overlap the previous field of view by 10°, which allows greater clarity in observing the periphery of an area.	X	X
4. No stop should last longer than 2 or 3 sec.	X	X
• Shape of silhouettes		
1. Because visual acuity is reduced, objects must be identified by their shape or silhouettes. Crew members must be familiar with the architectural design of structures in the area.	X	---
2. Features depicted on the map will also aid in recognizing silhouettes.	X	---

Army Aviation Manuals Summary of Contents	FM 1-301 1987	TC 1-204 1988
Distance Estimation and Depth Perception Cues (Day and Night)		
• Monocular cues		
1. Motion parallax	X	X
2. Geometric perspective (linear perspective, apparent foreshortening, vertical position in the field)	X	X
3. Retinal image size (known size of objects, increasing or decreasing size of objects, terrestrial associations, overlapping contours or interposition of objects)	X	X
4. Aerial perspective (fading of colors or shades, position of light source or direction of shadow, loss of detail or texture)	X	X
• Binocular cues	X	X
Visual Illusions		
• Autokinesis	X	X
• Relative motion	X	X
• False horizons	X	X
• Confusing ground lights with stars	X	X
• Size-distance illusion	X	X
• Flicker vertigo	X	X
• Fascination (fixation) in flying	X	X
• Reversible perspective illusion	X	X
• Altered planes of reference	X	X
• Height perception illusion (depth perception illusion)	X	X
• Structural illusions	X	X
Meteorological Conditions and Night Vision		
• Because it is difficult to detect adverse weather at night, crew members should be constantly aware of changing conditions.	X	---
• As cloud coverage increases, visual acuity and contrast of terrain features are lost.	X	---
• If the moon and stars cannot be seen, clouds are present.	X	---
• The clouds obscuring the moon's illumination causes shadows.	X	---
• The halo effect observed around ground lights indicates the presence of moisture and possibly ground fog.	X	---
• The presence of fog over water surfaces indicates that the temperature and dew point are equal. It also indicates that fog may soon form over ground areas.	X	---

Army Aviation Manuals Summary of Contents	FM 1-301 1987	TC 1-204 1988
Self-Imposed Stress, Vision, and Night Flying		
• *Drugs* seriously degrade visual acuity during the day and especially at night.	X	X
• *Exhaustion* reduces mental alertness and causes crew members to respond more slowly. Crew members are prone to stare rather than using proper scanning techniques.	X	X
1. Illness with increased temperature may cause oxygen to be consumed at a higher rate than normal, and hypoxia may be induced. Also a feeling of unpleasantness interferes with concentration.	X	X
2. Poor physical conditioning may lead to fatigue and night scanning inefficiency.	X	X
3. Inadequate rest can lead to exhaustion and decrease night flying ability.	X	X
• *Alcohol* causes incoordination and impairs judgment which hinders an aviator's ability to use proper scanning techniques.	X	X
• *Cigarette smoking* decreases visual sensitivity the most of all self-imposed stressors. Smoking increases carbon monoxide, which reduces the blood's capability to carry oxygen, resulting in hypoxia. This in turn affects peripheral vision and dark adaptation. The results are the same as those for hypoxia caused by high altitudes. Smokers lose 20% of their night vision capability at sea level.	X	X
• *Hypoglycemia and nutritional deficiency* affect vision. Missing or postponing meals can cause low blood sugar levels, impairing night vision performance. A diet deficient in *Vitamin A* can also impair night vision.	X	X
Nerve Agents and Night Vision		
• When exposed to minute amounts of nerve agent, the pupils constrict (miosis) and do not dilate in low ambient light. Severe miosis results in the inability to see in low ambient light.	X	X
• Discussion of symptoms and exposure time.	X	X

Army Aviation Manuals Summary of Contents	FM 1-301 1987	TC 1-204 1988
Terrain Interpretation		
• Visual recognition cues		
1. Object size	---	X
2. Object shape	---	X
3. Contrast (ambient light; color, texture, and background)	---	X
• Interpretation factors		
1. Ambient light	---	X
2. Viewing distance	---	X
3. Flight altitude	---	X
4. Moon altitude	---	X
5. Visibility restriction	---	X
6. Terrain	---	X
7. Seasons	---	X

[a] With full dark adaptation, after 30 to 45 minutes, the sensitivity of the eye increases 100,000 times (Boff & Lincoln, 1988).

[b] The 2-minute time to regain dark adaptation after removal of night vision goggles stated in the manuals was based on research where individuals wore goggles (AN/PVS-5) for only five minutes. The time required to dark adapt after wearing goggles for a longer period of time such as 2 or 4 hours, has not been investigated yet, but is most likely greater than 2 minutes.

Vehicle Driving Manuals

Current Manual

TC 21-305-2. (1990). *Night Vision Goggles: Training Program for Night Vision Goggle Driving Operations.*

Driving Manuals Summary of Contents	TC 21-305-2 1990
Anatomy/Physiology of the Eye	
• Describes parts of the eye (lens, iris, retina, pupil, optic nerve).	X
• Describes how eye is similar to a camera.	X
Types of Vision	
• Describes photopic, mesopic, and scotopic vision, and the consequences of each for visual acuity and color perception.	X
• Defines normal visual acuity as 20/20.	X
• Sources of ambient light at night:	
1. Moon; light from moon is brightest when moon is at its highest point in the sky.	X
2. Background lighting such as stars and aurora.	X
3. Artificial lights from cities, cars, fires and flares.	X
4. Solar light exists for certain periods following sunset and before sunrise.	X
Visual Problems Affecting Night Vision	
• Presbyopia: common to individuals over 40, lose ability to read maps and instruments especially in red light, correctable with bifocal lenses.	X
• Night Myopia: occurs in person who is nearsighted (myopic), will experience blurred vision, special lenses will correct.[a]	X
• Astigmatism: produces an out-of-focus condition in the eye, correctable with lenses.[b]	X
Dark Adaptation in General	
• Takes about 30 to 45 minutes.	X
• Exposure to flare or lightning may require 5 to 45 minutes to recover.[c]	X

Driving Manuals Summary of Contents	TC 21-305-2 1990
Self-imposed Stresses	
• Smoking: Smokers lose 20% of their night vision capability at sea level.	X
• Alcohol: Impairs coordination and judgment.	X
• Fatigue: Reduces reaction time to night emergencies.	X
• Nutrition: Hunger can lead to shortened attention span; failure to eat foods that provide sufficient Vitamin A can reduce night vision.	X
• Physical conditioning: Good physical conditioning will result in less fatigue during night driving; however, too much exercise on a given day may be tiring.	X
• Sleep: Rest and sleep are required before night driving, as it is more tiring and stressful than day driving.	X
• Nerve Agents: Night vision is adversely affected by exposure of the eyes to small amounts of nerve agents.	X
Depth Perception	
• Defined as quality of seeing objects as three-dimensional.	X
• Cues used to aid distance estimation and depth perception (linear perspective, apparent foreshortening, vertical position in the field, motion parallax, and retinal image size).[b]	X
Visual Illusions	
• Autokinesis: When staring at a still light in the dark, it will appear to move in about 8 to 10 sec.	X
• Relative Motion and Structural Illusions[b].	X
Night Tactical Operations Precautions	
• If a flash or high-intensity light expected, turn vehicle away from light source. If direction not known, close one eye.	X
• Reason given for closing one eye. Dark adaptation is protected in that eye; dark adaptation occurs independently in each eye.	X
• Select routes to avoid built-up areas where light is concentrated.	X
• Maneuver vehicle away from a flare or high-intensity light source to the edge of the lighted area.	X
• Use short bursts of fire when using automatic weapons.	X

[a] Night myopia refers to the tendency of individuals to become nearsighted at night.

[b] Not unique to night.

[c] A more complete and accurate statement is that the time to recover depends on the intensity and duration of the light. Of the two examples given, lightning will not greatly affect dark adaptation; a flare would affect dark adaptation more.

APPENDIX C

COMPARISON OF CURRENT GROUND FORCE FIELD MANUALS WITH THE UNAIDED NIGHT VISION PROGRAM

Current manuals refer to:

FM 21-75 (1984), *Combat Skills of the Soldier*
FM 7-8 (1992), *Infantry Rifle Platoon and Squad*
FM 7-92 (1992), *The Infantry Recon Platoon and Squad*

Table C1
The Dark Adaptation Process

What Soldiers Need to Know about Dark Adaptation	What the Current FMs say	What the Final Unaided Program Provides
Time Required to Dark Adapt		
• Bright lights to dark	• 30 minutes	• 30-45 minutes
• In the field	• Does not mention	• When in the field from daylight to night time, you dark adapt as the light level decreases. If you wake up in the middle of the night, you are dark adapted.
Dark Adaptation Curve • Shape and reason for curve [Cones adapt during first 5 to 10 minutes; rods continue adapting for 20 to 30 minutes longer.]	• Does not mention	• Cones adapt rapidly; rods increase in sensitivity for a period of 30 to 45 minutes.
Increased Sensitivity of Eyes when Dark Adapted	• 10,000 times after 30 min.	• 100,000 times when fully dark adapted
Individual Differences in the Rate of Dark Adaptation	• People dark adapt at different rates.	• People's dark adaptation rates may vary depending on such factors as age, smoking, and physical condition.

What Soldiers Need to Know about Dark Adaptation	What the Current FMs say	What the Final Unaided Program Provides
Changes in the Eye During Dark Adaptation (Increase of Visual Purple - Rhodopsin)		
• Composition	• Does not mention	• A derivative of Vitamin A
• Location	• Does not mention	• Located in the rods
• Purpose	• Does not mention	• To assist in dark adaptation through a photochemical response
• How visual purple reacts to lights	• Does not mention	• Visual purple is bleached out or depleted during levels of high illumination.
• How visual purple reacts to darkness	• Does not mention	• The amount of visual purple increases with exposure to darkness.
• Implications for night operations	• Exposure to bright sunlight impairs ability to dark adapt.	• Exposure to bright sunlight impairs ability to dark adapt.
		• Wear military-issue neutral density sunglasses in sunlight. Time to dark adapt without wearing sunglasses can be 3 to 4 hours versus the normal 30-45 minutes.
	• Night vision goggles (NVGs) impair dark adaptation. Two minutes to adapt again after removing goggles if dark adapted prior.	• FMs say 2 minutes to adapt after removing NVGs. Time to dark adapt after removing NVGs probably varies with wearing time and intensity of the light; more definitive research needed.
		• Maintain a diet with sufficient amounts of Vitamin A. Do not take Vitamin A supplements; they can be harmful.

Table C2
The Three Types of Vision

What Soldiers Need to Know about the Three Types of Vision	What Current FMs Say	What the Final Unaided Program Provides
Daylight Vision (Photopic)		
• When it occurs	• Does not mention	• Occurs under maximum lighting such as when the sun is shining or in a well lit room
• Part of eye responsible	• Does not mention	• Cone cells. • Cones are located throughout the retina (central and peripheral), but are concentrated in central part (the fovea). They provide what is called central vision.
• Ability to see detail; visual acuity	• Does not mention directly	• Visual acuity is defined. A person with 20/20 vision can clearly see an object placed 20 feet away. 20/100 is also defined. • Visual acuity is at its best; 20/20 or 20/15 vision is possible; sharpest images.
• Ability to see color	• Does not mention	• Colors are most vivid under day light conditions.
• Depth perception	• Does not mention	• Depth perception not discussed. {Reference to cones facilitating stereopsis, or very accurate depth perception, deleted because of misinterpretations by instructors and soldiers.}
• Reaction time	• Does not mention	• Best reaction time is possible

What Soldiers Need to Know about the Three Types of Vision	What Current FMs Say	What the Final Unaided Program Provides
Twilight Vision (Mesopic)		
• When it occurs	• Does not mention directly. FMs do not discriminate between mesopic and scotopic vision.	• Occurs at dawn or dusk, down to full moonlight; when there is artificial illumination; with snow on the ground at night; during the day with several layers of jungle canopy.
• Part(s) of the eye responsible	• Does not mention	• Rods and cones; but less cones than in daylight. Use both central and peripheral vision.
• Ability to see detail; visual acuity	• Does not mention directly	• Visual acuity is poorer. The best visual acuity under these conditions is between 20/50 and 20/100.
• Ability to see color	• Does not mention	• Color vision is poorer. Colors are visible, but not as vivid as in daylight.
• Depth perception	• Does not mention	• Does not mention
• Reaction time	• Does not mention	• Reaction times are slowed because of reduced light levels.

What Soldiers Need to Know about the Three Types of Vision	What Current FMs Say	What the Final Unaided Program Provides
Night Vision (Scotopic) • When it occurs	• Does not mention. FMs do not discriminate between scotopic and mesopic vision.	• Occurs on a starlit night, as well as on moonless and cloudy nights.
• Part of eye responsible	• Does not mention directly	• Rod cells. Cone cells do not function under these conditions. • Rods are in the peripheral retina only, which partially explains why one does not have central vision at night.
• Ability to see detail; visual acuity	• Visual acuity is 1/7 at night what it is during the day. [FM should state this is under full moonlight.]	• The best visual acuity under these conditions is 20/200 to 20/400 (at least 10 times worse than day vision). Visual acuity is equivalent to seeing the big E on the eye chart. 20/200 and 20/400 acuity defined.

What Soldiers Need to Know about the Three Types of Vision	What Current FMs Say	What the Final Unaided Program Provides
Night Vision (Scotopic) • Ability to see detail (continued)	• Only large, bulky objects can be seen. Object identification is based on contours and outlines.	• One can recognize silhouettes, but not details of objects. Silhouette demonstration included in program.
• Ability to see color	• Can discriminate light and dark colors depending on the intensity of reflected light.	• No color vision with only rods functioning. If colors can be seen (e.g., bright flare), the light is bright enough to activate the cone cells, and thus color vision.
• Reaction time	• Does not mention	• Reaction time is the slowest because only rods cells are being used.
• Depth perception	• Depth perception is affected.	• Does not mention directly.
• The night blind spot	• See Table C3 on the Night Blind Spot.	• See Table C3 on the Night Blind Spot.

Table C3
The Night (Central) Blind Spot

What Soldiers Need to Know about the Night Blind Spot	What Current FMs Say	What the Final Unaided Program Provides
Definition of the Night Blind Spot	• Not defined, but term is presented. • Viewing with central vision is ineffective at night.	• The central part of the retina is not sensitive at night; there are no rods in the fovea and the cones in the fovea do not function at night. • Therefore, one cannot see objects at night using central vision.
Consequences of the Night Blind Spot	• When you stare at something at night, it can disappear or fade away.	• If one stares at something at night, it can disappear or fade away. • As distances increase, larger and larger objects can be missed. A hand grenade at 6 feet can be missed; a M1 tank at 2000 feet can be missed; soldiers report cat-eyes on the back of helmets disappear when following others at night. • Other examples and demonstrations of the night blind spot are provided in the program.

What Soldiers Need to Know about the Night Blind Spot	What Current FMs Say	What the Final Unaided Program Provides
How to Overcome the Night Blind Spot		
• Scanning Techniques (Off-center viewing, diamond viewing)	• Look to all sides of the object you are trying to see.	• Scanning allows one to keep an object in focus when viewed at night.
	• Do not stare. View the object by looking 10° above, below or to either side. Use peripheral vision.	• Do not stare. View objects with peripheral vision, not with central vision, which is the opposite of is done during the day. Look to all the sides of the object you are trying to see by using a diamond-shaped viewing pattern, i.e., diamond viewing.
		• Diamond viewing is practiced.
	• Avoid looking at an object/area for more than 2 or 3 seconds to avoid the bleach-out effect.	• The diamond-viewing demonstration illustrates the "bleach-out" effect.
• Factors Inhibiting Scanning at Night	• Does not mention	• Soldiers must overcome daytime habits. They must do exactly the opposite of what is done during the day to see objects at night; scan instead of stare.
		• When soldiers are under stress at night, concerned about a break in contact during movement, etc. they will resort to habit. They will tend to stare at the person in front of them.
		• Fatigue causes individuals to stare rather than use proper scanning techniques.

Table C4
The Normal (Physiological) Blind Spot

What Soldiers Need to Know about the Normal Blind Spot	What Current FMs Say	What the Final Unaided Program Provides
Definition of the Normal Blind Spot	• Does not define	• The normal blind spot is caused by the lack of light receptors where the optic nerve inserts into the back of the eye. • It is present both day and night. • It is typically not experienced because the visual fields of both eyes overlap. What one eye does not see, the other will see. • Demonstration provided.
Consequences of the Normal Blind Spot	• Does not mention	• Can adversely affect the ability to function in the field under certain conditions. When covering one eye to preserve dark adaptation, the normal blind spot may be experienced.
How to Overcome the Normal Blind Spot	• Does not mention	• When using one eye, can compensate for the normal blind spot by scanning.

Table C5
Color Vision

What Soldiers Need to Know about Color Vision	What Current FMs Say	What the Final Unaided Program Provides
Receptors Responsible for Color Vision	• Does not mention	• Cones are responsible for color vision and are located in the fovea and the peripheral retina.
Ability to See Colors as Illumination Decreases		
• General effects	• Color perception decreases; may distinguish light and dark colors with high intensity light.	• Can lose all color vision under the lowest light levels (scotopic conditions). Colors less vivid under mesopic or twilight conditions.
• Sensitivity to different wavelengths of light; to different colors	• {Two statements made about red and blue light are incorrect -- Blue light more difficult to see than red; blue light not hamper night vision.}	• Under low light levels, (such as dusk and night) the longer wavelengths of light, such as reds and oranges are harder to see and will appear dark. Greens and blues will appear brighter. Red is considered a camouflage color.
		• Dark adaptation is maintained under red light as the rods are not sensitive to reds (see also Table C6).

What Soldiers Need to Know about Color Vision	What Current FMs Say	What the Final Unaided Program Provides
Ability to See Colors as Illumination Decreases (*continued*)		
• Role of rods and cones	• Does not mention	• Cones are responsible for color-vision. Colors cannot be seen with rods. When colors are seen, the cones are functioning.
• Purkinje shift	• Does not mention	• Defined: Cones are more sensitive to longer wave-lengths of light, such as reds. Rods are more sensitive to shorter wave-lengths, like blue-green. • Due to the eyes' increased sensitivity to blue-green light and decreased sensitivity to red light at low levels of illumination, looking 20-30° away from red and green-blue light sources will make the green-blue light appear brighter or even white and make the red light disappear. Demonstration provided.
Field Applications		
• Distances at which different colors from different sources can be seen	• Does not mention	• Blue and green can be seen from the greatest distance using peripheral vision. For example, blue and green strobe lights are easier to see from a distance than amber or orange strobes. No specific distances provided.
• Purkinje shift	• Does not mention	• On large landing zones, where different colored strobe lights were used to designate different company assembly areas, troops have indicated that the colors of the strobes disappear. Do not assume that a white light seen in the periphery is white; it may be another color.

What Soldiers Need to Know about Color Vision	What Current FMs Say	What the Final Unaided Program Provides
***Field Applications** (continued)* • Why Pathfinders Use Patterns of Lights for Marking	• Does not mention	• Since colored lights are often difficult to see at night, particularly on drop zones and landing zones, pathfinders often use distinct patterns of light instead for marking purposes (e.g., lights which form the shape of different letters). A specific pattern of lights may also be used to indicate when a mission is canceled.
• Colored smoke	• Does not mention	• Colored smoke is invisible at night.
• Landmarks	• Does not mention	• Colors of objects will not look the same at night as they do during the day. • Red landmarks will be invisible.
• Why red lines and markings are not readable under red light and red goggles	• Does not mention	• Reason provided in program (reflection of red light source makes red markings disappear). Example: why maps have been made "red light readable," that is, able to be read with a red lens filter in a flashlight.

Table C6
Protecting Dark Adaptation Before Night Operations

What Soldiers Need to Know about Protecting Dark Adaptation before Night Operations	What Current FMs Say	What the Final Unaided Program Provides
Exposure to Sunlight	• Does not mention	• Dark adaptation can be greatly impaired (3 to 4 hours), if eyes are exposed to bright sunlight. Military issue sunglasses should be worn prior to night operations.
Effects of Smoking	• Does not mention	• Not smoking 4-6 hours prior to night operations will aid in dark adaptation. • Smoking can cause hypoxia, or lack of oxygen to the blood. This decreases the rod cells' ability to dark adapt, increasing the time to dark adapt.
Effects of Diet • Levels of Vitamin A	• Does not mention.	• Good nutrition is important in order to maintain adequate levels of Vitamin A. • Excessive amounts of Vitamin A will not improve dark adaptation and can be toxic.
• What foods contain Vitamin A	• Does not mention.	• Sufficient Vitamin A is in a normal diet if dairy products, leafy vegetables, and poultry are eaten.
• Relationship to visual purple	• Does not mention.	• Visual purple is a chemical derivative of Vitamin A; lack of Vitamin A impairs night vision.

What Soldiers Need to Know about Protecting Dark Adaptation before Night Operations	What Current FMs Say	What the Final Unaided Program Provides
Use of Dim White and/or Red Lighting	• Does not mention.	• Use dim white light in a confined space prior to night operations. A single 40 watt light bulb in a medium size space (15 x 15 ft) is about right. • Red lights are used to facilitate dark adaptation prior to airborne jumps.

Table C7
Maintaining Dark Adaptation During Night Operations

What Soldiers Need to Know about Maintaining Dark Adaptation	What Current FMs Say	What the Final Unaided Program Provides
Exposure to Lights • Minimize bright light	• Exposure to bright lights have an adverse affect on dark adaptation. Full recovery can take up to 45 minutes.	• Avoid using headlights, search lights, or flashlights. If in a brightly lit area, other lighting is not necessary. Never compromise your safety, however. • Minimize use of unnecessary lighting. Use dim white lighting in a confined space such as a TOC.
• Avoid looking at lights	• Does not mention	• If you know you are going to be exposed to bright lights (flares, headlights, cannon lights, etc.), close one eye prior to being flashed. This will preserve dark adaptation. Demonstration provided. • Exposure to light of short duration (tracers, strobes) does not affect dark adaptation, especially if not looked at directly. Demonstration provided.
• Use of red light	• Facilitate dark adaptation by staying in red-lighted area or by wearing red goggles.	• Red lighting will preserve dark adaptation. Also, to remain camouflaged, use red lighting. It will be the least visible color to dark-adapted people. Blue-green or white lights will be visible over long distances, while reds will not. Working under a poncho or tarp ensures the enemy cannot see your lights.

What Soldiers Need to Know about Maintaining Dark Adaptation	What Current FMs Say	What the Final Unaided Program Provides
Effects of Night Vision Goggles	• Goggles affect dark adaptation. If adapted prior to donning goggles, dark adaptation can be regained within 2 min. after removal.	• The Army literature says it takes 2 minutes to dark adapt after wearing goggles, which was based on research goggles were worn for only 5 minutes. The time required to dark adapt after wearing goggles for a longer period of time (2 or 4 hours) has not been investigated yet, but it most likely is greater than 2 minutes.

Table C8
Visual Illusions

What Soldiers Need to Know about Visual Illusions at Night	What Current FMs Say	What the Final Unaided Program Provides
The Autokinetic Effect or Autokinesis		
• Definition	• Does not define	• The illusion of movement which a static light exhibits when stared at in the dark. • Demonstration provided.
• Explanation of why it occurs	• Does not mention	• It occurs because of the loss of surrounding visual references which normally serve to stabilize visual perceptions. Very small eye movements are perceived by the brain as movement of the light.
• Consequences of the illusion	• Does not mention	• The light could be a chem light or cigarette of an enemy soldier. You may not be able to tell if the enemy is moving or if it is just your eyes. • The autokinetic illusion has caused several aviation accidents because people have followed stationary lights thinking they were lights on planes in flight.
• How it can be overcome	• Does not mention	• Use visual scanning techniques; use large eye movements. • Demonstration provided. • Pathfinders mark landing zones with at least two lights which are separated appropriately to prevent this illusion.

What Soldiers Need to Know about Visual Illusions at Night	What Current FMs Say	What the Final Unaided Program Provides
• Situations where Autokinesis Can Occur	• Does not mention	• Observing a single ground based light at night, particularly if you are elevated. • Looking at a prominent bright star • A single approach light from a distant aircraft coming directly at you.
Purkinje Shift - Refer to Table C5 on Color Vision	• Does not mention	• Refer to Table C5 on Color Vision

Table C9

Maximizing Unaided Visual Capability at Night and Other Operational Considerations

What Soldiers need to Know about Maximizing their Unaided Night Vision Capability	What Current FMs Say	What the Final Unaided Program Provides
Scanning Techniques	• See Table C3 on the Night Blind Spot	• See Table C3 on the Night Blind Spot
Silhouette Recognition	• Soldiers must recognize objects by their shape or outline. Knowing the design of structures common to the area enhances success.	• Objects with distinct silhouettes or outlines are good target reference points. Certain architectural features can be identified easily. • Avoid "sky lining" by moving and camouflaging yourself and equipment so as to not present a distinctive outline.
Use of Prescription Lenses	• Does not mention	• The use of prescription lenses will help you see objects more clearly at night, even though they may not be needed during the day. Lenses help reduce the blur created by the eyes' imperfect focusing system at night.
Use of Colored Signals and Markers	• Does not mention	• Remember that colors are perceived differently at night. Blue-greens can appear white at a distance using peripheral vision; reds can disappear. • Red is a camouflage color.

Table C10

Anatomy and Physiology of the Eye

What Soldiers Need to Know about the Eye	What the Current FMs say	What the Final Unaided Program Provides
Parts of the Eye • Cornea	• Does not mention	• The clear part of the eye where light enters. It bends the light so that it focuses clearly on the back of the eye.
• Iris	• Does not mention	• The colored part of the eye located behind the cornea.
• Pupil	• Does not mention	• The hole in the middle of the iris. At night it gets larger to let more light into the back of the eye; however, it may focus light imperfectly because of the eye's imperfect optics. Wearing glasses at night counters this effect. In bright light, the pupil gets smaller helping the light to focus clearly on the retina.
• Lens	• Does not mention	• The saucer shaped structure located behind the pupil. It helps to focus light on the back of the eye and gives individuals the ability to focus on objects located closer than 20 feet. This is called accommodation. • Bifocals or reading glasses are needed for people over 40 because the lens hardens, and therefore cannot accommodate as easily.

What Soldiers Need to Know about the Eye	What the Current FMs say	What the Final Unaided Program Provides
***Parts of the Eye** (continued)* • Lens (continued)	• Does not mention	• The lens focusing system does not work well at night. Also, under red light conditions, it is even more difficult to focus because red lights make people more farsighted.
• Retina	• Does not mention	• When light gets to the back of the eye, it focuses on the fovea. The rest of the retina is the peripheral retina, which is used for peripheral vision and is primarily responsible for night vision.
• Rods and cones	• Does not mention	• Rods and cones are the light receptors on the retina. There are approximately 7 million cones throughout the retina. They are concentrated in the fovea (the center) and decrease in number away from the fovea. There are 20 times more rods than cones. There are no rods in the fovea; they are only on the peripheral retina and increase in number away from the fovea.
• Optic nerve	• Does not mention	• The optic nerve inserts into the peripheral retina, connecting the eye to the brain. There are no light receptors at this point, resulting in the normal blind spot.
Illustration of the Eye	• Does not provide illustration	• Provides large, labeled illustration of the parts of the eye

APPENDIX D
TEST RESPONSES: EXPERIMENTS A AND B AND THE JRTC

Table D1

Percentage Responding to Each Item on the Posttest for the Program Group

[Under Experiment A the "I" stands for Instructors, the "L" stands for Leaders, and the "S" stands for Students. Under Experiment B the "L" stands for Leaders and the "AR" stands for Army Reserve].

Item (Posttest for Program Group)	Correct Answer	JRTC	Experiment A			Experiment B	
		O/Cs	I	L	S	L	AR
1. It takes approx. _____ minutes for a person with normal, healthy vision to completely dark adapt	30-45						
5 minutes or less		6	6	0	14	0	0
6-10 minutes		0	0	0	7	0	0
11-19 minutes		0	0	0	0	0	0
20-29 minutes		0	6	0	0	0	0
30-45 minutes		95	88	100	80	100	100
> than 45 minutes		0	0	0	0	0	0
2. Which of the following enhances your ability to see at night?	D						
a. eating a candy bar for quick energy before night operations.		0	0	0	0	0	0
b. using chewing tobacco at night.		0	0	0	0	0	0
c. supplementing a balanced diet with Vitamin A.		75	31	53	27	53	63
d. reducing your exposure to intense light during the day.		25	69	47	73	40	38
[no answer]		0	0	0	0	7	0
3. Visual purple is a chemical in the rod cells of our eyes responsible for	C						
a. our ability to see colors during the day.		0	6	20	0	13	13
b. the color of our eyes.		0	6	0	0	0	0
c. our ability to see at night.		94	88	67	100	53	88
d. enabling us to directly view objects at night from great distances.		6	0	13	0	33	0
4. Fatigue during night operations result in	A						
a. a tendency to stare at objects.		88	75	67	60	67	75
b. the inability to see objects clearly		13	25	33	40	27	25
c. a decrease in blood sugar level, which causes poor reaction time.		0	0	0	0	0	0
d. a loss of color vision.		0	0	0	0	7	0

Item (Posttest for Program Group)	Correct Answer	JRTC	Experiment A			Experiment B	
		O/Cs	I	L	S	L	AR
5. Which of the following statements is true?	B						
a. The rods are primarily responsible for day vision, and the cones are primarily responsible for night vision.		0	13	27	27	20	13
b. The rods are primarily responsible for night vision, and the cones are primarily responsible for day vision.		100	88	73	73	80	88
6. What is the best way to maintain dark adaptation when you are unexpectedly exposed to a bright light, such as a search light?	A						
a. close one eye and avoid looking directly into the lights.		100	100	100	100	93	100
b. view lights peripherally by focusing on a distant object.		0	0	0	0	0	0
c. alternate between brief periods of viewing directly and looking away.		0	0	0	0	0	0
d. slowly move your eyes around the light source in a diamond-pattern.		0	0	0	0	7	0
7. Approximately how long will a soldier have to be exposed to a searchlight at night before it begins to seriously interfere with his dark adaptation?	B						
a. less than a minute		56	81	53	40	53	75
b. 3-5 minutes		38	6	33	53	40	25
c. 10-15 minutes		0	6	13	7	7	0
d. 20-25 minutes		0	6	0	0	0	0
[no answer]		6	0	0	0	0	0
8. Diamond viewing or off-center vision techniques may best be defined as follows:	C						
a. scanning a large area to maximize your field of view		19	13	13	20	33	13
b. the technique used to protect your dark adaptation from bright sources of light		0	0	0	0	13	0
c. looking to all sides of the object you wish to see		81	81	87	67	47	88
d. a technique used to discriminate between colors at night		0	6	0	7	7	0
[no answer]		0	0	0	7	0	0
9. As light levels decrease, our eyes become more sensitive to (are more likely to see) what colors?	D						
a. red-orange		0	19	13	7	13	31
b. orange-yellow		0	13	7	20	7	6
c. blue-violet		0	6	0	7	13	0
d. blue-green		100	63	80	67	67	63

Item (Posttest for Program Group)	Correct Answer	JRTC	Experiment A			Experiment B	
		O/Cs	I	L	S	L	AR
10. Due to the night blind spot, which of the following objects is most likely to be missed when viewed at a distance of approximately 6 feet?	B						
a. a tank		0	0	7	0	0	0
b. a hand grenade		100	94	93	100	80	88
c. an enemy soldier		0	6	0	0	20	13
d. a howitzer		0	0	0	0	0	0
11. On a dark night, a school bus can be most easily distinguished by	B						
a. the yellow paint and black lettering on its sides		6	19	20	27	53	25
b. its shape or outline		75	69	60	53	33	50
c. the number of windows and amount of glass		6	6	0	0	7	0
d. the size and location of the red caution lights		13	6	20	20	7	25
12. The vision that may occur during the daytime under several layers of jungle canopy is comparable to the vision we have during which of the following conditions?	B						
a. night		0	13	7	20	13	13
b. twilight		88	75	67	73	53	75
c. starlight		0	6	7	0	0	6
d. no moonlight and no stars		13	6	20	7	33	6
13. What is the best degree of visual acuity we have on a moonless night?	D						
a. 20/20		13	13	7	27	13	25
b. 20/50		0	13	20	20	20	31
c. 20/100		13	19	60	7	60	31
d. 20/200		75	56	13	47	7	13
e. 20/400		0	0	0	0	0	0
14. We have a night blind spot because:	B						
a. there are no light cells (receptors) where the optic nerve inserts in the retina		31	56	27	33	33	50
b. the central part of the retina contains only those light cells which function during the day		50	13	20	47	40	25
c. the number of light cells in the retina decreases at night		6	13	20	7	7	0
d. the central part of the retina contains very few of the light cells which function at night		13	19	27	7	20	19
[no answer]		0	0	7	7	0	6

Item (Posttest for Program Group)	Correct Answer	JRTC	Experiment A			Experiment B	
		O/Cs	I	L	S	L	AR
15. Under which light condition is the ability to recognize silhouettes most critical?	C						
a. twilight		0	19	27	20	33	6
b. daylight		0	6	7	0	0	0
c. moonless night		94	75	60	53	53	81
d. dusk		6	0	7	20	13	13
[no answer]		0	0	0	7	0	0
16. Dark adaptation progresses most quickly during	A						
a. the first 5 minutes		44	31	20	73	27	31
b. the second 5 minutes		6	13	27	13	20	19
c. the third 5 minutes		6	19	27	13	7	13
d. the fourth 5 minutes		44	38	13	0	47	38
[no answer]		0	0	13	0	0	0
17. Diamond viewing helps you to see:	A						
a. stationary and moving targets		88	69	67	80	40	25
b. only stationary targets		13	31	33	20	53	75
c. only moving targets		0	0	0	0	7	0
18. If a light appears to move in the night sky, how can you determine if the light is really moving?	D						
a. shift your gaze between the perceived moving light and an object on the ground		25	6	13	7	33	13
b. look away from the perceived moving light for 10 to 20 seconds and then look back towards the perceived moving light again		0	6	13	0	13	31
c. ask someone else if the light is moving; you may be fatigued and should not trust your own judgment		0	0	0	0	0	6
d. shift your gaze between the perceived moving light and another light in the sky		75	88	73	93	53	50
19. After your eyes are thoroughly dark adapted, the exposure of one eye to bright light will result in	D						
a. a complete loss of dark adaptation in the exposed eye		0	6	7	0	0	6
b. a complete loss of dark adaptation in both eyes		0	0	0	0	0	0
c. no loss of dark adaptation to either eye		0	0	0	7	7	0
d. a loss of dark adaptation in the exposed eye for a short time		100	94	93	87	93	94
[no answer]		0	0	0	7	0	0

Item (Posttest for Program Group)	Correct Answer	JRTC	Experiment A			Experiment B	
		O/Cs	I	L	S	L	AR
20. A soldier on night operations is following others in a file and reports that the cat-eyes on the back of the helmet of a soldier a few paces ahead have disappeared. Why is the soldier unable to view the cat-eyes?	A						
a. the soldier was looking directly at the cat-eyes		100	94	100	100	100	100
b. the soldier was standing too close to the person directly in front		0	0	0	0	0	0
c. there was little moonlight or starlight		0	0	0	0	0	0
d. the soldier was using peripheral vision to view the cat-eyes		0	6	0	0	0	0
21. Which of the following will interfere most seriously with dark adaptation?	D						
a. looking at the instrument panel of a vehicle		0	0	0	0	0	0
b. observing the lights of a city skyline		0	6	0	0	0	0
c. lighting a cigarette		13	13	13	20	33	25
d. 5 minutes in a TOC with bright white light		88	81	87	80	67	75
22. Under twilight conditions, we are able to see	C						
a. only black, white, and shades of gray		31	25	33	27	60	44
b. colors as clearly as under daylight conditions		0	6	0	0	0	0
c. colors, but not as clearly as under daylight conditions		69	63	67	67	27	50
d. reds, greens, and blues only		0	6	0	7	13	6
23. What is the hardest color for our eyes to see at night from a distance?	B						
a. blue		0	0	7	0	0	6
b. red		94	100	93	87	93	88
c. yellow		0	0	0	13	0	0
d. green		6	0	0	0	7	6
24. The most important change during dark adaptation is:	C						
a. an increase in the size of the pupil		19	56	27	73	27	25
b. a change in the shape of the lens		0	13	13	0	7	6
c. an increase in the amount of visual purple		69	25	47	13	33	56
d. an increase in the number of rod cells		13	6	13	7	33	13
[no answer]		0	0	0	7	0	0

Item (Posttest for Program Group)	Correct Answer	JRTC	Experiment A			Experiment B	
		O/Cs	I	L	S	L	AR
25. If you do not look directly at flashing strobe lights or tracer rounds, how long will your dark adaptation be affected?	D						
a. 10 seconds or less		31	44	27	27	20	44
b. 1-2 minutes		6	31	20	0	33	25
c. 5-10 minutes		0	0	7	0	7	6
d. dark adaptation will not be affected		63	25	47	73	40	19
[no answer]		0	0	0	0	0	6
26. Wearing military-issue sunglasses on sunny days helps you to dark adapt at night because:	A						
a. your visual purple is less likely to be "bleached out"		63	25	87	67	47	50
b. your rod cells are activated before it gets dark		13	25	0	7	13	19
c. you actually start dark adapting during the day		19	44	13	7	40	25
d. the glasses block the functioning of cone cells		6	6	0	13	0	0
[no answer]		0	0	0	7	0	6
27. A soldier with 20/20 vision can clearly see	D						
a. an object that is 20 feet high and 20 feet away		0	13	13	7	7	13
b. an object better than someone with 20/10 vision		6	0	0	7	13	0
c. 20 feet further when viewing with one eye than when viewing with two eyes		0	6	0	0	0	0
d. an object placed 20 feet away		94	81	87	87	73	88
[no answer]		0	0	0	0	7	0
28. Which part(s) of the eye operate under bright sunshine?	C						
a. rods and cones		0	25	20	27	13	13
b. rods only		0	0	13	20	13	6
c. cones only		100	75	67	53	73	81
29. Which of the following is true if a soldier has 20/400 vision at night?	B						
a. At night, he must be 20 feet closer to see objects which are 400 feet away		6	25	20	13	47	13
b. For objects seen at 400 feet during the day, he must be 20 feet away to see them at night		94	75	80	80	53	75
[no answer]		0	0	0	7	0	13

Item (Posttest for Program Group)	Correct Answer	JRTC	Experiment A			Experiment B	
		O/Cs	I	L	S	L	AR
30. Staring directly at an object at night:	A						
a. can make it disappear		100	100	100	93	100	100
b. can make it brighter		0	0	0	0	0	0
c. allows you to see the object's details more clearly		0	0	0	7	0	0
d. can make it seem smaller		0	0	0	0	0	0
31. Which of the following is a condition under which both the rods and the cones of the eye are operating?	B						
a. moonless night		6	6	0	20	7	0
b. dusk		38	63	60	67	73	56
c. cloudy nights		6	6	7	7	0	0
d. starlight		50	19	33	7	20	44
[no answer]		0	6	0	0	0	0
32. The primary reason we have no color vision, sharply reduced visual acuity, and slow reaction times under very dark conditions is that:	A						
a. The cone cells cannot function at night		81	69	53	60	67	69
b. The rod cells cannot function at night		0	13	13	33	7	0
c. The rod cells are not sensitive to small amounts of light		0	19	27	0	7	13
d. There are no cone cells on the periphery of the retina		19	0	7	7	20	13
[no answer]		0	0	0	0	0	6
33. What can occur if you stare at a non-moving, isolated light at night?	C						
a. the light will appear to change color		0	0	0	0	7	0
b. the light will appear to become brighter		0	6	0	7	7	6
c. the light will appear to move		100	94	93	93	87	94
d. the light will appear to become larger		0	0	0	0	0	0
[no answer]		0	0	7	0	0	0
34. At long distances at night, all colors, whatever their source, may appear to be white.	A						
a. True		88	44	73	67	67	81
b. False		13	56	27	33	33	19

Item (Posttest for Program Group)	Correct Answer	JRTC	Experiment A			Experiment B	
		O/Cs	I	L	S	L	AR
35. If exposed to a bright light after total dark adaptation has taken place, it will take at least 30-45 minutes to regain the same level of dark adaptation.	B						
a. True		44	19	13	33	27	6
b. False		56	81	87	67	73	94
36. The best way to discriminate between colors at night is to use your peripheral vision.	B						
a. True		63	63	53	53	80	88
b. False		38	38	47	47	20	13
37. There are more rod cells in the retina than cone cells.	A						
a. True		63	44	60	53	73	81
b. False		38	56	40	47	27	13
[no answer]		0	0	0	0	0	6
38. It is easy for medics to see blood on a casualty at night.	B						
a. True		0	0	0	7	13	0
b. False		100	100	100	93	87	100
39. If you have 20/20 vision during the day, you will also have 20/20 vision at night.	B						
a. True		0	6	7	13	20	25
b. False		100	94	93	80	80	69
[no answer]		0	0	0	7	0	6
40. The normal blind spot is present during both the day and night.	A						
a. True		44	56	27	47	67	88
b. False		56	44	73	53	33	13
41. You can see better at night if you wear your prescription glasses, even though you may not need them in the day.	A						
a. True		94	75	87	80	73	75
b. False		6	25	13	13	27	25
[no answer]		0	0	0	7	0	0

Item (Posttest for Program Group)	Correct Answer	JRTC	Experiment A			Experiment B	
		O/Cs	I	L	S	L	AR
42. Smoking 4 to 6 hours prior to night operations may affect your dark adaptation.	A						
a. True		81	88	87	93	100	100
b. False		19	13	13	7	0	0
43. Alcohol should be avoided prior to night operations because it inhibits the ability of the pupil in your eye to change shape.	B						
a. True		88	75	93	87	100	100
b. False		13	25	7	13	0	0
44. The best way to see an object on a starlit night is to look away from it about 10-15 degrees rather than directly at it.	A						
a. True		100	88	93	80	93	88
b. False		0	13	7	20	7	13
45. Exposure to lightning will not greatly affect your level of dark adaptation.	A						
a. True		69	50	60	73	40	44
b. False		31	50	40	27	60	50
[no answer]		0	0	0	0	0	6
46. Colored smoke makes a good marker at night because the different colors are clearly distinguishable.	B						
a. True		0	6	0	13	7	0
b. False		100	94	100	87	93	100
47. When you wake up in the middle of the night you are already dark adapted.	A						
a. True		50	50	100	47	47	25
b. False		50	50	0	53	53	75
48. Individuals dark adapt at the same rate.	B						
a. True		0	0	0	7	7	0
b. False		100	100	100	93	93	100
49. Your reaction time is slower during twilight than during daylight.	A						
a. True		94	94	87	80	100	94
b. False		6	6	13	13	0	6
[no answer]		0	0	0	7	0	0

Item (Posttest for Program Group)	Correct Answer	JRTC	Experiment A			Experiment B	
		O/Cs	I	L	S	L	AR
50. Looking to the side of a red light at night may result in the light appearing white.	A						
a. True		81	63	73	67	40	81
b. False		19	38	27	33	60	13
[no answer]		0	0	0	0	0	6

Table D2

Percentage Responding to Each Item on the Initial Test for the No Program Group

[Under Experiment A the "I" stands for Instructors, the "L" stands for Leaders, and the "S" stands for Students. Under Experiment B the "L" stands for Leaders, and the "AR" stands for Army Reserve]

Item (Initial Test for No Program Group)	Correct Answer	Experiment A			Experiment B	
		I	L	S	L	AR
1. It takes approx. _____ minutes for a person with normal, healthy vision to completely dark adapt	30-45					
5 minutes or less		13	14	20	7	6
6-10 minutes		13	0	7	7	12
11-19 minutes		7	13	7	13	19
20-29 minutes		13	7	40	7	12
30-45 minutes		54	67	20	67	44
> than 45 minutes		0	0	7	0	6
2. Which of the following enhances your ability to see at night?	D					
a. eating a candy bar for quick energy before night operations.		0	0	0	0	0
b. using chewing tobacco at night.		0	0	0	0	0
c. supplementing a balanced diet with Vitamin A.		20	27	27	67	38
d. reducing your exposure to intense light during the day.		80	73	73	33	63
3. Visual purple is a chemical in the rod cells of our eyes responsible for	C					
a. our ability to see colors during the day.		13	7	13	0	13
b. the color of our eyes.		7	7	0	7	6
c. our ability to see at night.		60	60	73	67	63
d. enabling us to directly view objects at night from great distances.		20	20	13	27	13
[no answer]		0	7	0	0	6
4. Fatigue during night operations result in	A					
a. a tendency to stare at objects.		40	27	27	27	31
b. the inability to see objects clearly		60	67	60	60	56
c. a decrease in blood sugar level, which causes poor reaction time.		0	7	13	7	13
d. a loss of color vision.		0	0	0	7	0

Item (Initial Test for No Program Group)	Correct Answer	Experiment A			Experiment B	
		I	L	S	L	AR
5. Which of the following statements is true?	B					
a. The rods are primarily responsible for day vision, and the cones are primarily responsible for night vision.		27	53	40	20	44
b. The rods are primarily responsible for night vision, and the cones are primarily responsible for day vision.		73	40	53	80	56
[no answer]		0	7	7	0	0
6. What is the best way to maintain dark adaptation when you are unexpectedly exposed to a bright light, such as a search light?	A					
a. close one eye and avoid looking directly into the lights.		87	73	100	73	88
b. view lights peripherally by focusing on a distant object.		7	7	0	13	6
c. alternate between brief periods of viewing directly and looking away.		7	0	0	0	0
d. slowly move your eyes around the light source in a diamond-pattern.		0	13	0	13	6
[no answer]		0	7	0	0	0
7. Approximately how long will a soldier have to be exposed to a searchlight at night before it begins to seriously interfere with his dark adaptation?	B					
a. less than a minute		80	87	73	93	94
b. 3-5 minutes		20	13	27	0	6
c. 10-15 minutes		0	0	0	7	0
d. 20-25 minutes		0	0	0	0	0
8. Diamond viewing or off-center vision techniques may best be defined as follows:	C					
a. scanning a large area to maximize your field of view		27	0	27	33	6
b. the technique used to protect your dark adaptation from bright sources of light		13	40	20	33	31
c. looking to all sides of the object you wish to see		60	47	53	33	50
d. a technique used to discriminate between colors at night		0	7	0	0	6
[no answer]		0	7	0	0	6
9. As light levels decrease, our eyes become more sensitive to (are more likely to see) what colors?	D					
a. red-orange		7	13	27	13	19
b. orange-yellow		33	33	40	60	50
c. blue-violet		27	20	13	13	19
d. blue-green		33	33	20	7	13
[no answer]		0	0	0	7	0

Item (Initial Test for No Program Group)	Correct Answer	Experiment A			Experiment B	
		I	L	S	L	AR
10. Due to the night blind spot, which of the following objects is most likely to be missed when viewed at a distance of approximately 6 feet?	B					
a. a tank		0	13	7	13	13
b. a hand grenade		80	67	87	60	69
c. an enemy soldier		20	13	7	20	13
d. a howitzer		0	7	0	0	6
[no answer]		0	0	0	7	0
11. On a dark night, a school bus can be most easily distinguished by	B					
a. the yellow paint and black lettering on its sides		27	20	13	33	13
b. its shape or outline		60	33	40	27	81
c. the number of windows and amount of glass		7	20	0	20	0
d. the size and location of the red caution lights		7	27	47	13	6
[no answer]		0	0	0	7	0
12. The vision that may occur during the daytime under several layers of jungle canopy is comparable to the vision we have during which of the following conditions?	B					
a. night		20	7	13	7	6
b. twilight		60	60	47	60	69
c. starlight		7	0	13	0	6
d. no moonlight and no stars		13	33	27	33	13
[no answer]		0	0	0	0	6
13. What is the best degree of visual acuity we have on a moonless night?	D					
a. 20/20		13	13	13	20	13
b. 20/50		20	20	27	13	31
c. 20/100		33	47	20	53	50
d. 20/200		27	13	13	13	0
e. 20/400		7	7	20	0	6
[no answer]		0	0	7	0	0

Item (Initial Test for No Program Group)	Correct Answer	Experiment A			Experiment B	
		I	L	S	L	AR
14. We have a night blind spot because:	B					
a. there are no light cells (receptors) where the optic nerve inserts in the retina		7	13	13	20	31
b. the central part of the retina contains only those light cells which function during the day		20	33	7	7	25
c. the number of light cells in the retina decreases at night		27	27	40	20	19
d. the central part of the retina contains very few of the light cells which function at night		47	27	33	53	19
[no answer]		0	0	7	0	6
15. Under which light condition is the ability to recognize silhouettes most critical?	C					
a. twilight		13	20	40	7	31
b. daylight		7	0	0	0	0
c. moonless night		53	47	27	47	38
d. dusk		27	33	33	47	31
16. Dark adaptation progresses most quickly during	A					
a. the first 5 minutes		40	27	40	53	38
b. the second 5 minutes		27	40	27	20	13
c. the third 5 minutes		20	7	13	27	19
d. the fourth 5 minutes		13	20	20	0	31
[no answer]		0	7	0	0	0
17. Diamond viewing helps you to see:	A					
a. stationary and moving targets		27	47	40	53	38
b. only stationary targets		53	33	60	33	50
c. only moving targets		20	20	0	7	6
[no answer]		0	0	0	7	6
18. If a light appears to move in the night sky, how can you determine if the light is really moving?	D					
a. shift your gaze between the perceived moving light and an object on the ground		40	40	53	27	38
b. look away from the perceived moving light for 10 to 20 seconds and then look back towards the perceived moving light again		13	7	7	13	6
c. ask someone else if the light is moving; you may be fatigued and should not trust your own judgment		0	7	0	7	0
d. shift your gaze between the perceived moving light and another light in the sky		47	47	40	53	56

Item (Initial Test for No Program Group)	Correct Answer	Experiment A			Experiment B	
		I	L	S	L	AR
19. After your eyes are thoroughly dark adapted, the exposure of one eye to bright light will result in	D					
a. a complete loss of dark adaptation in the exposed eye		13	20	7	13	0
b. a complete loss of dark adaptation in both eyes		7	7	0	13	6
c. no loss of dark adaptation to either eye		0	0	0	0	0
d. a loss of dark adaptation in the exposed eye for a short time		80	73	93	73	94
20. A soldier on night operations is following others in a file and reports that the cat-eyes on the back of the helmet of a soldier a few paces ahead have disappeared. Why is the soldier unable to view the cat-eyes?	A					
a. the soldier was looking directly at the cat-eyes		73	47	60	60	56
b. the soldier was standing too close to the person directly in front		0	0	0	7	0
c. there was little moonlight or starlight		20	33	20	13	6
d. the soldier was using peripheral vision to view the cat-eyes		7	20	20	20	38
21. Which of the following will interfere most seriously with dark adaptation?	D					
a. looking at the instrument panel of a vehicle		0	0	0	0	6
b. observing the lights of a city skyline		0	7	0	0	6
c. lighting a cigarette		13	20	20	27	13
d. 5 minutes in a TOC with bright white light		87	73	80	73	75
22. Under twilight conditions, we are able to see	C					
a. only black, white, and shades of gray		60	60	67	33	44
b. colors as clearly as under daylight conditions		0	13	0	0	0
c. colors, but not as clearly as under daylight conditions		27	20	27	53	56
d. reds, greens, and blues only		13	7	0	13	0
[no answer]		0	0	7	0	0
23. What is the hardest color for our eyes to see at night from a distance?	B					
a. blue		67	73	73	40	44
b. red		7	7	7	20	13
c. yellow		13	0	7	0	6
d. green		13	20	13	40	38

Item (Initial Test for No Program Group)	Correct Answer	Experiment A			Experiment B	
		I	L	S	L	AR
24. The most important change during dark adaptation is:	C					
a. an increase in the size of the pupil		60	100	67	73	75
b. a change in the shape of the lens		0	0	0	0	0
c. an increase in the amount of visual purple		40	0	27	0	19
d. an increase in the number of rod cells		0	0	7	27	6
25. If you do not look directly at flashing strobe lights or tracer rounds, how long will your dark adaptation be affected?	D					
a. 10 seconds or less		20	27	27	13	63
b. 1-2 minutes		27	20	27	13	25
c. 5-10 minutes		0	13	0	7	0
d. dark adaptation will not be affected		53	40	47	67	13
26. Wearing military-issue sunglasses on sunny days helps you to dark adapt at night because:	A					
a. your visual purple is less likely to be "bleached out"		20	27	33	27	25
b. your rod cells are activated before it gets dark		7	13	7	33	6
c. you actually start dark adapting during the day		53	33	47	13	50
d. the glasses block the functioning of cone cells		20	20	7	27	19
[no answer]		0	7	7	0	0
27. A soldier with 20/20 vision can clearly see	D					
a. an object that is 20 feet high and 20 feet away		13	20	27	13	38
b. an object better than someone with 20/10 vision		7	13	7	7	25
c. 20 feet further when viewing with one eye than when viewing with two eyes		20	33	0	7	6
d. an object placed 20 feet away		60	27	60	73	31
[no answer]		0	7	7	0	0
28. Which part(s) of the eye operate under bright sunshine?	C					
a. rods and cones		40	27	20	13	13
b. rods only		20	27	33	7	31
c. cones only		33	40	33	80	50
[no answer]		7	7	13	0	6

Item (Initial Test for No Program Group)	Correct Answer	Experiment A			Experiment B	
		I	L	S	L	AR
29. Which of the following is true if a soldier has 20/400 vision at night?	B					
a. At night, he must be 20 feet closer to see objects which are 400 feet away		13	27	20	7	31
b. For objects seen at 400 feet during the day, he must be 20 feet away to see them at night		87	67	80	93	69
[no answer]		0	7	0	0	0
30. Staring directly at an object at night:	A					
a. can make it disappear		93	93	80	87	88
b. can make it brighter		0	0	0	0	0
c. allows you to see the object's details more clearly		0	7	0	0	6
d. can make it seem smaller		7	0	20	13	6
31. Which of the following is a condition under which both the rods and the cones of the eye are operating?	B					
a. moonless night		20	27	7	7	19
b. dusk		33	33	47	60	56
c. cloudy nights		13	7	0	7	6
d. starlight		33	33	47	27	19
32. The primary reason we have no color vision, sharply reduced visual acuity, and slow reaction times under very dark conditions is that:	A					
a. The cone cells cannot function at night		13	27	27	53	25
b. The rod cells cannot function at night		27	13	20	7	13
c. The rod cells are not sensitive to small amounts of light		33	33	40	0	31
d. There are no cone cells on the periphery of the retina		27	13	0	40	31
[no answer]		0	13	13	0	0
33. What can occur if you stare at a non-moving, isolated light at night?	C					
a. the light will appear to change color		7	7	0	13	0
b. the light will appear to become brighter		20	20	47	20	6
c. the light will appear to move		60	60	33	60	69
d. the light will appear to become larger		13	13	20	7	25
34. At long distances at night, all colors, whatever their source, may appear to be white.	A					
a. True		27	47	40	67	56
b. False		73	53	60	33	44

Item (Initial Test for No Program Group)	Correct Answer	Experiment A			Experiment B	
		I	L	S	L	AR
35. If exposed to a bright light after total dark adaptation has taken place, it will take at least 30-45 minutes to regain the same level of dark adaptation.	B					
a. True		60	73	53	67	31
b. False		40	27	47	33	69
36. The best way to discriminate between colors at night is to use your peripheral vision.	B					
a. True		87	53	87	80	56
b. False		13	47	13	20	44
37. There are more rod cells in the retina than cone cells.	A					
a. True		47	53	47	7	63
b. False		53	40	33	93	31
[no answer]		0	7	20	0	6
38. It is easy for medics to see blood on a casualty at night.	B					
a. True		13	0	0	13	13
b. False		87	100	100	87	88
39. If you have 20/20 vision during the day, you will also have 20/20 vision at night.	B					
a. True		0	13	20	27	38
b. False		100	87	80	73	63
40. The normal blind spot is present during both the day and night.	A					
a. True		20	60	27	27	44
b. False		80	40	67	73	56
[no answer]		0	0	7	0	0
41. You can see better at night if you wear your prescription glasses, even though you may not need them in the day.	A					
a. True		73	47	73	53	75
b. False		27	47	27	47	25
[no answer]		0	7	0	0	0

Item (Initial Test for No Program Group)	Correct Answer	Experiment A			Experiment B	
		I	L	S	L	AR
42. Smoking 4 to 6 hours prior to night operations may affect your dark adaptation.	A					
a. True		80	47	47	60	63
b. False		20	47	53	40	38
[no answer]		0	7	0	0	0
43. Alcohol should be avoided prior to night operations because it inhibits the ability of the pupil in your eye to change shape.	B					
a. True		87	87	93	93	88
b. False		13	13	7	7	6
[no answer]		0	0	0	0	6
44. The best way to see an object on a starlit night is to look away from it about 10-15 degrees rather than directly at it.	A					
a. True		80	93	87	93	94
b. False		20	7	13	7	6
45. Exposure to lightning will not greatly affect your level of dark adaptation.	A					
a. True		33	47	60	33	38
b. False		67	53	40	67	63
46. Colored smoke makes a good marker at night because the different colors are clearly distinguishable.	B					
a. True		0	13	7	7	6
b. False		100	87	87	93	94
[no answer]		0	0	7	0	0
47. When you wake up in the middle of the night you are already dark adapted.	A					
a. True		47	60	33	53	56
b. False		53	40	67	47	44
48. Individuals dark adapt at the same rate.	B					
a. True		13	20	0	0	6
b. False		87	80	100	100	94
49. Your reaction time is slower during twilight than during daylight.	A					
a. True		73	93	87	87	75
b. False		27	7	13	13	25

Item (Initial Test for No Program Group)	Correct Answer	Experiment A			Experiment B	
		I	L	S	L	AR
50. Looking to the side of a red light at night may result in the light appearing white.	A					
a. True		40	53	47	33	44
b. False		60	47	47	67	50
[no answer]		0	0	7	0	6

Table D3

Percentage Responding to Each Item on the Retest for the No Program Group

[Under Experiment A the "I" stands for Instructors, the "L" stands for Leaders, and the "S" stands for Students. Under Experiment B the "L" stands for Leaders and the "AR" stands for Army Reserve]

Item (Retest No Program Group)	Correct Answer	Experiment A			Experiment B	
		I	L	S	L	AR
1. It takes approx. _____ minutes for a person with normal, healthy vision to completely dark adapt	30-45					
5 minutes or less		7	21	0	0	0
6-10 minutes		0	0	0	0	0
11-19 minutes		0	0	0	0	0
20-29 minutes		0	7	7	0	0
30-45 minutes		93	74	95	100	100
> than 45 minutes		0	0	0	0	0
2. Which of the following enhances your ability to see at night?	D					
a. eating a candy bar for quick energy before night operations.		0	0	0	7	0
b. using chewing tobacco at night.		0	0	0	0	0
c. supplementing a balanced diet with Vitamin A.		33	47	47	40	63
d. reducing your exposure to intense light during the day.		67	53	53	53	38
3. Visual purple is a chemical in the rod cells of our eyes responsible for	C					
a. our ability to see colors during the day.		7	7	7	13	6
b. the color of our eyes.		7	7	0	0	0
c. our ability to see at night.		87	87	87	80	94
d. enabling us to directly view objects at night from great distances.		0	0	7	7	0
4. Fatigue during night operations result in	A					
a. a tendency to stare at objects.		47	93	73	73	75
b. the inability to see objects clearly		47	7	20	20	6
c. a decrease in blood sugar level, which causes poor reaction time.		0	0	0	0	6
d. a loss of color vision.		7	0	7	7	13
5. Which of the following statements is true?	B					
a. The rods are primarily responsible for day vision, and the cones are primarily responsible for night vision.		0	0	20	7	13
b. The rods are primarily responsible for night vision, and the cones are primarily responsible for day vision.		100	100	80	93	88

Item (Retest No Program Group)	Correct Answer	Experiment A			Experiment B	
		I	L	S	L	AR
6. What is the best way to maintain dark adaptation when you are unexpectedly exposed to a bright light, such as a search light?	A					
a. close one eye and avoid looking directly into the lights.		87	87	93	87	100
b. view lights peripherally by focusing on a distant object.		7	7	0	0	0
c. alternate between brief periods of viewing directly and looking away.		7	0	0	0	0
d. slowly move your eyes around the light source in a diamond-pattern.		0	7	7	7	0
[no answer]		0	0	0	7	0
7. Approximately how long will a soldier have to be exposed to a searchlight at night before it begins to seriously interfere with his dark adaptation?	B					
a. less than a minute		60	80	13	60	50
b. 3-5 minutes		40	20	60	27	38
c. 10-15 minutes		0	0	27	0	6
d. 20-25 minutes		0	0	0	13	6
8. Diamond viewing or off-center vision techniques may best be defined as follows:	C					
a. scanning a large area to maximize your field of view		27	20	7	13	0
b. the technique used to protect your dark adaptation from bright sources of light		0	7	20	7	0
c. looking to all sides of the object you wish to see		73	73	67	80	100
d. a technique used to discriminate between colors at night		0	0	7	0	0
9. As light levels decrease, our eyes become more sensitive to (are more likely to see) what colors?	D					
a. red-orange		13	20	7	7	6
b. orange-yellow		7	13	13	7	6
c. blue-violet		13	0	13	7	6
d. blue-green		67	67	67	80	81
10. Due to the night blind spot, which of the following objects is most likely to be missed when viewed at a distance of approximately 6 feet?	B					
a. a tank		0	0	0	0	0
b. a hand grenade		93	87	100	93	100
c. an enemy soldier		7	13	0	7	0
d. a howitzer		0	0	0	0	0

Item (Retest No Program Group)	Correct Answer	Experiment A			Experiment B	
		I	L	S	L	AR
11. On a dark night, a school bus can be most easily distinguished by	B					
a. the yellow paint and black lettering on its sides		13	20	20	13	6
b. its shape or outline		80	67	67	87	81
c. the number of windows and amount of glass		0	0	0	0	6
d. the size and location of the red caution lights		7	13	13	0	6
12. The vision that may occur during the daytime under several layers of jungle canopy is comparable to the vision we have during which of the following conditions?	B					
a. night		7	20	7	0	0
b. twilight		80	53	67	80	94
c. starlight		0	20	7	0	0
d. no moonlight and no stars		13	7	20	20	0
[no answer]		0	0	0	0	6
13. What is the best degree of visual acuity we have on a moonless night?	D					
a. 20/20		0	27	0	13	31
b. 20/50		0	13	13	0	6
c. 20/100		40	27	7	20	38
d. 20/200		53	13	73	67	25
e. 20/400		7	20	7	0	0
14. We have a night blind spot because:	B					
a. there are no light cells (receptors) where the optic nerve inserts in the retina		60	27	33	33	38
b. the central part of the retina contains only those light cells which function during the day		27	47	27	20	25
c. the number of light cells in the retina decreases at night		0	7	20	13	13
d. the central part of the retina contains very few of the light cells which function at night		7	20	20	27	25
[no answer]		7	0	0	7	0
15. Under which light condition is the ability to recognize silhouettes most critical?	C					
a. twilight		27	33	27	27	25
b. daylight		0	13	0	0	0
c. moonless night		73	53	60	73	69
d. dusk		0	0	13	0	6

Item (Retest No Program Group)	Correct Answer	Experiment A			Experiment B	
		I	L	S	L	AR
16. Dark adaptation progresses most quickly during	A					
a. the first 5 minutes		33	47	20	60	38
b. the second 5 minutes		7	20	7	13	6
c. the third 5 minutes		20	13	27	13	13
d. the fourth 5 minutes		40	20	47	13	44
17. Diamond viewing helps you to see:	A					
a. stationary and moving targets		53	67	60	53	44
b. only stationary targets		47	33	40	47	56
c. only moving targets		0	0	0	0	0
18. If a light appears to move in the night sky, how can you determine if the light is really moving?	D					
a. shift your gaze between the perceived moving light and an object on the ground		7	13	7	20	50
b. look away from the perceived moving light for 10 to 20 seconds and then look back towards the perceived moving light again		7	0	7	40	6
c. ask someone else if the light is moving; you may be fatigued and should not trust your own judgment		0	7	0	0	0
d. shift your gaze between the perceived moving light and another light in the sky		87	80	87	40	44
19. After your eyes are thoroughly dark adapted, the exposure of one eye to bright light will result in	D					
a. a complete loss of dark adaptation in the exposed eye		7	20	7	0	0
b. a complete loss of dark adaptation in both eyes		0	7	0	0	0
c. no loss of dark adaptation to either eye		7	0	0	0	6
d. a loss of dark adaptation in the exposed eye for a short time		87	73	93	100	94
20. A soldier on night operations is following others in a file and reports that the cat-eyes on the back of the helmet of a soldier a few paces ahead have disappeared. Why is the soldier unable to view the cat-eyes?	A					
a. the soldier was looking directly at the cat-eyes		87	93	100	100	94
b. the soldier was standing too close to the person directly in front		0	0	0	0	0
c. there was little moonlight or starlight		0	7	0	0	0
d. the soldier was using peripheral vision to view the cat-eyes		13	0	0	0	6

Item (Retest No Program Group)	Correct Answer	Experiment A			Experiment B	
		I	L	S	L	AR
21. Which of the following will interfere most seriously with dark adaptation?	D					
a. looking at the instrument panel of a vehicle		0	0	0	0	6
b. observing the lights of a city skyline		0	7	0	0	13
c. lighting a cigarette		13	7	7	0	0
d. 5 minutes in a TOC with bright white light		87	87	93	100	81
22. Under twilight conditions, we are able to see	C					
a. only black, white, and shades of gray		27	40	27	40	31
b. colors as clearly as under daylight conditions		7	0	0	0	0
c. colors, but not as clearly as under daylight conditions		53	60	60	53	50
d. reds, greens, and blues only		13	0	13	7	19
23. What is the hardest color for our eyes to see at night from a distance?	B					
a. blue		0	0	7	0	6
b. red		87	93	93	100	81
c. yellow		0	7	0	0	6
d. green		13	0	0	0	6
24. The most important change during dark adaptation is:	C					
a. an increase in the size of the pupil		40	53	33	7	38
b. a change in the shape of the lens		0	0	0	7	6
c. an increase in the amount of visual purple		53	47	67	80	44
d. an increase in the number of rod cells		7	0	0	7	13
25. If you do not look directly at flashing strobe lights or tracer rounds, how long will your dark adaptation be affected?	D					
a. 10 seconds or less		33	33	40	53	56
b. 1-2 minutes		7	20	7	13	6
c. 5-10 minutes		13	0	0	0	0
d. dark adaptation will not be affected		47	47	53	33	38

Item (Retest No Program Group)	Correct Answer	Experiment A			Experiment B	
		I	L	S	L	AR
26. Wearing military-issue sunglasses on sunny days helps you to dark adapt at night because:	A					
a. your visual purple is less likely to be "bleached out"		87	53	67	20	38
b. your rod cells are activated before it gets dark		0	0	13	27	19
c. you actually start dark adapting during the day		13	33	20	53	44
d. the glasses block the functioning of cone cells		0	13	0	0	0
27. A soldier with 20/20 vision can clearly see	D					
a. an object that is 20 feet high and 20 feet away		20	27	13	13	44
b. an object better than someone with 20/10 vision		13	7	0	7	0
c. 20 feet further when viewing with one eye than when viewing with two eyes		0	7	0	0	0
d. an object placed 20 feet away		67	60	87	80	56
28. Which part(s) of the eye operate under bright sunshine?	C					
a. rods and cones		13	7	7	7	6
b. rods only		0	7	7	7	0
c. cones only		87	87	87	87	94
29. Which of the following is true if a soldier has 20/400 vision at night?	B					
a. At night, he must be 20 feet closer to see objects which are 400 feet away		13	20	20	7	13
b. For objects seen at 400 feet during the day, he must be 20 feet away to see them at night		87	80	80	93	88
30. Staring directly at an object at night:	A					
a. can make it disappear		93	93	100	100	94
b. can make it brighter		0	7	0	0	0
c. allows you to see the object's details more clearly		7	0	0	0	0
d. can make it seem smaller		0	0	0	0	6
31. Which of the following is a condition under which both the rods and the cones of the eye are operating?	B					
a. moonless night		0	7	0	7	6
b. dusk		73	60	73	27	56
c. cloudy nights		0	13	0	0	0
d. starlight		27	20	27	67	38

Item (Retest No Program Group)	Correct Answer	Experiment A			Experiment B	
		I	L	S	L	AR
32. The primary reason we have no color vision, sharply reduced visual acuity, and slow reaction times under very dark conditions is that:	A					
a. The cone cells cannot function at night		87	73	80	73	75
b. The rod cells cannot function at night		7	7	13	7	0
c. The rod cells are not sensitive to small amounts of light		0	13	7	0	13
d. There are no cone cells on the periphery of the retina		7	7	0	20	13
33. What can occur if you stare at a non-moving, isolated light at night?	C					
a. the light will appear to change color		0	7	0	0	6
b. the light will appear to become brighter		7	7	0	0	6
c. the light will appear to move		93	87	100	93	88
d. the light will appear to become larger		0	0	0	7	0
34. At long distances at night, all colors, whatever their source, may appear to be white.	A					
a. True		67	80	87	80	75
b. False		33	20	13	20	25
35. If exposed to a bright light after total dark adaptation has taken place, it will take at least 30-45 minutes to regain the same level of dark adaptation.	B					
a. True		20	47	7	20	13
b. False		80	53	93	80	88
36. The best way to discriminate between colors at night is to use your peripheral vision.	B					
a. True		80	40	80	80	63
b. False		20	60	20	20	38
37. There are more rod cells in the retina than cone cells.	A					
a. True		67	60	67	87	56
b. False		33	40	33	13	44
38. It is easy for medics to see blood on a casualty at night.	B					
a. True		0	13	0	0	0
b. False		100	87	100	100	100

Item (Retest No Program Group)	Correct Answer	Experiment A			Experiment B	
		I	L	S	L	AR
39. If you have 20/20 vision during the day, you will also have 20/20 vision at night.	B					
a. True		0	20	7	7	50
b. False		100	80	93	93	50
40. The normal blind spot is present during both the day and night.	A					
a. True		47	73	67	73	88
b. False		53	27	33	27	13
41. You can see better at night if you wear your prescription glasses, even though you may not need them in the day.	A					
a. True		93	93	100	67	94
b. False		7	7	0	33	6
42. Smoking 4 to 6 hours prior to night operations may affect your dark adaptation.	A					
a. True		100	100	93	93	88
b. False		0	0	7	7	13
43. Alcohol should be avoided prior to night operations because it inhibits the ability of the pupil in your eye to change shape.	B					
a. True		60	100	93	100	100
b. False		40	0	7	0	0
44. The best way to see an object on a starlit night is to look away from it about 10-15 degrees rather than directly at it.	A					
a. True		100	80	93	93	100
b. False		0	20	7	7	0
45. Exposure to lightning will not greatly affect your level of dark adaptation.	A					
a. True		53	47	87	47	81
b. False		47	53	13	53	19
46. Colored smoke makes a good marker at night because the different colors are clearly distinguishable.	B					
a. True		0	7	7	7	6
b. False		100	93	93	93	94

Item (Retest No Program Group)	Correct Answer	Experiment A			Experiment B	
		I	L	S	L	AR
47. When you wake up in the middle of the night you are already dark adapted.	A					
a. True		47	60	47	47	75
b. False		53	40	53	53	25
48. Individuals dark adapt at the same rate.	B					
a. True		0	13	0	13	6
b. False		100	87	100	87	94
49. Your reaction time is slower during twilight than during daylight.	A					
a. True		93	87	100	93	94
b. False		7	13	0	7	6
50. Looking to the side of a red light at night may result in the light appearing white.	A					
a. True		67	93	80	60	94
b. False		33	7	20	40	6

APPENDIX E

CLASSIFICATION OF TEST ITEMS: EXPERIMENTS A AND B

Table E1
Classification of Each Test Item Used in Experiments A and B

Item #	Program Topic	Importance	Program Presentation
1*	DA - General	Important	Technical
2*	Protect DA	Important	Application
3*	Visual Purple	Important	Technical
4	Protect DA	Less Important	Technical
5*	Rods and Cones	Important	Technical
6*	DA and Lights	Important	Demonstration
7	DA and Lights	Less Important	Application
8	Viewing Techniques	Important	Demonstration
9	Color Perception	Important	Demonstration
10	Viewing Techniques	Less Important	Demonstration
11*	Visual Acuity	Important	Application
12*	Visual Acuity	Less Important	Technical
13*	Visual Acuity	Less Important	Technical
14*	Blind Spot	Less Important	Technical
15	Visual Acuity	Important	Application
16	DA - General	Less Important	Application
17*	Viewing Techniques	Important	Demonstration
18	Autokinesis	Less Important	Demonstration
19*	DA and Lights	Important	Demonstration
20*	Blind Spot	Less Important	Technical
21*	DA and Lights	Less Important	Application
22*	Color Perception	Less Important	Technical
23	Color Perception	Important	Demonstration
24*	Visual Purple	Less Important	Technical

Item #	Program Topic	Importance	Program Presentation
25*	DA and Lights	Important	Demonstration
26*	Visual Purple	Less Important	Application
27*	Visual Acuity	Important	Technical
28*	Rods and Cones	Important	Technical
29*	Visual Acuity	Less Important	Application
30*	Blind Spot	Important	Demonstration
31*	Rods and Cones	Less Important	Technical
32*	Rods and Cones	Less Important	Technical
33*	Autokinesis	Important	Demonstration
34*	Color Perception	Less Important	Application
35*	DA and Lights	Less Important	Technical
36	Color Perception	Less Important	Application
37*	Rods and Cones	Less Important	Technical
38*	Color Perception	Less Important	Application
39	Visual Acuity	Important	Application
40*	Blind Spot	Less Important	Technical
41*	Visual Acuity	Important	Technical
42*	Protect DA	Less Important	Technical
43	Protect DA	Less Important	Technical
44	Viewing Techniques	Less Important	Technical
45*	DA and Lights	Less Important	Application
46*	Color Perception	Less Important	Application
47*	DA - General	Less Important	Application
48*	DA - General	Less Important	Technical
49	Reaction Time	Important	Technical
50*	Color Perception	Important	Demonstration

Note. DA stands for dark adaptation. * indicates the items common to all tests in Experiments A, B, and C.

Table E2

Crosswalk Between Items Classified by Importance of Material and Method of Program Presentation - Experiments A and B

Program Presentation	Importance of Material		Total # of Items
	Important	Less Important	
Demonstration	6, 8, 9, 17, 19, 23, 25, 30, 33, 50	10, 18	12
Technical	1, 3, 5, 27, 28, 41, 49	4, 12, 13, 14, 20, 22, 24, 31, 32, 35, 37, 40, 42, 43, 44, 48	23
Application	2, 11, 15, 39	7, 16, 21, 26, 29, 34, 36, 38, 45, 46, 47	15
Total # of Items	21	29	50

Note. Item numbers are cited in the cells.

APPENDIX F
TEST RESPONSES: EXPERIMENT C

Table F1

Percentage Responding to Each Item on the Post and Retention Tests for the Program Group
[Under Experiment C the OSUTP stands for the OSUT Posttest, and OSUTR stands for the OSUT Retention Test]

Item (Test for Program Group)	Correct Answer	Experiment C	
		OSUTP	OSUTR
1. It takes approx. _____ minutes for a person with normal, healthy vision to completely dark adapt	30-45		
5 minutes or less		0	17
6-10 minutes		0	0
11-19 minutes		0	10
20-29 minutes		0	3
30-45 minutes		100	67
> than 45 minutes		0	3
2. Which of the following enhances your ability to see at night?	D		
a. eating a candy bar for quick energy before night operations.		0	0
b. using chewing tobacco at night.		0	0
c. supplementing a balanced diet with Vitamin A.		30	23
d. reducing your exposure to intense light during the day.		63	77
[no answer]		8	0
3. Visual purple is a chemical in the rod cells of our eyes responsible for	C		
a. our ability to see colors during the day.		5	10
b. the color of our eyes.		0	3
c. our ability to see at night.		90	80
d. enabling us to directly view objects at night from great distances.		3	7
[no answer]		3	0

Item (Test for Program Group)	Correct Answer	Experiment C	
		OSUTP	OSUTR
4. Fatigue during night operations result in	A		
a. a tendency to stare at objects.		75	
b. the inability to see objects clearly		20	
c. a decrease in blood sugar level, which causes poor reaction time.		3	
d. a loss of color vision.		3	
4. Fatigue during night operations result in	A		
a. a tendency to stare at objects.			77
b. the inability to see objects clearly			17
c. a decrease in the ability to see distant lights			0
d. a loss of color vision			7
5. Which of the following statements is true?	B		
a. The rods are primarily responsible for day vision, and the cones are primarily responsible for night vision.		20	40
b. The rods are primarily responsible for night vision, and the cones are primarily responsible for day vision.		80	60
6. What is the best way to maintain dark adaptation when you are unexpectedly exposed to a bright light, such as a search light?	A		
a. close one eye and avoid looking directly into the lights.		85	87
b. view lights peripherally by focusing on a distant object.		8	3
c. alternate between brief periods of viewing directly and looking away.		0	0
d. slowly move your eyes around the light source in a diamond-pattern.		8	10

Item (Test for Program Group)	Correct Answer	Experiment C	
		OSUTP	OSUTR
7. Approximately how long will a soldier have to be exposed to a searchlight at night before it begins to seriously interfere with his dark adaptation?	B		
a. less than a minute		98	
b. 3-5 minutes		3	
c. 10-15 minutes		0	
d. 20-25 minutes		0	
7. Approximately how long will a soldier have to look at a searchlight at night before it interferes with his dark adaptation?	A		
a. less than a minute			83
b. 3-5 minutes			13
c. 5-10 minutes			3
d. more than 10 minutes			0
8. Diamond viewing or off-center vision techniques may best be defined as follows:	C		
a. scanning a large area to maximize your field of view		48	
b. the technique used to protect your dark adaptation from bright sources of light		5	
c. looking to all sides of the object you wish to see		45	
d. a technique used to discriminate between colors at night		0	
[no answer]		3	
8. Which of the following best defines diamond viewing:	C		
a. scanning, as you would during the day, to detect objects of military interest			13
b. looking away from a light source to protect your dark adaptation from bright lights			13
c. looking to all sides of the object you wish to see			67
d. a technique for discriminating between colors at night			7

Item (Test for Program Group)	Correct Answer	Experiment C	
		OSUTP	OSUTR
9. Due to the night blind spot, which of the following objects is most likely to be missed when viewed at a distance of approximately 6 feet?	B		
a. a tank		0	
b. a hand grenade		98	
c. an enemy soldier		3	
d. a howitzer		0	
9. Due to the night blind spot, which of the following is most likely to be missed when viewed from a distance of approximately 150 feet?	C		
a. a tank			23
b. a hand grenade			17
c. an enemy soldier			47
d. a large aircraft			13
10. On a dark night, a school bus can be most easily distinguished by	B		
a. the yellow paint and black lettering on its sides		25	37
b. its shape or outline		63	63
c. the number of windows and amount of glass		3	0
d. the size and location of the red caution lights		8	0
[no answer]		3	0
11. The vision that may occur during the daytime under several layers of jungle canopy is comparable to the vision we have during which of the following conditions?	B		
a. night		13	10
b. twilight		73	77
c. starlight		8	0
d. no moonlight and no stars		8	13
12. What is the best degree of visual acuity we have on a moonless night?	D		
a. 20/20		10	7
b. 20/50		20	13
c. 20/100		35	27
d. 20/200		28	30
e. 20/400		8	23

Item (Test for Program Group)	Correct Answer	Experiment C	
		OSUTP	OSUTR
13. We have a night blind spot because:	B		
a. there are no light cells (receptors) where the optic nerve inserts in the retina		33	27
b. the very central part of the retina contains only those light cells which function during the day		40	37
c. the number of light cells in the retina decreases at night		13	20
d. the peripheral retina contains very few of the light cells which function at night		15	17
14. During the period it takes to dark adapt, your ability to see at night:	B		
a. continues to improve the same amount with each minute		18	
b. is hindered at the very first, then improves fairly quickly, and then gradually gets better and better		13	
c. is hindered at the very first and then gradually gets better and better		65	
d. is poor throughout the period and only gets better at the end		5	
* question deleted on retention test			
50. To overcome the night blind spot, you must move your head from side to side.	B		
a. True		48	
b. False		53	
14. To overcome the night blind spot with diamond viewing, you scan by	B		
a. turning your head and moving it in a diamond pattern around the object of interest			7
b. shifting your eyes from the object of interest a few degrees and moving your eyes in a diamond pattern around it			83
c. moving both your head and your eyes in a diamond pattern around the object of interest			10
15. Diamond viewing helps you to see:	A		
a. stationary and moving targets		75	50
b. only stationary targets		25	50
c. only moving targets		0	0
16. After your eyes are thoroughly dark adapted, the exposure of one eye to bright light will result in	D		
a. a complete loss of dark adaptation in the exposed eye		23	13
b. a complete loss of dark adaptation in both eyes		5	0
c. no loss of dark adaptation to either eye		5	3
d. a loss of dark adaptation in the exposed eye for a short time		65	83
[no answer]		3	0

Item (Test for Program Group)	Correct Answer	Experiment C	
		OSUTP	OSUTR
17. A soldier on night operations is following others in a file and reports that the reflective tape on the back of the helmet of a soldier a few paces ahead have disappeared. Why is the soldier unable to view the tape?	A		
a. the soldier was looking directly at the tape		88	83
b. the soldier was standing too close to the person directly in front		0	0
c. there was little moonlight or starlight		0	0
d. the soldier was using peripheral vision to view the tape		13	17
18. Which of the following will interfere most seriously with dark adaptation?	D		
a. looking at the instrument panel of a vehicle		3	3
b. observing the lights of a city skyline		8	0
c. lighting a cigarette		15	20
d. 5 minutes in a tent with bright white light		73	77
[no answer]		3	0
19. Under twilight conditions, we are able to see	C		
a. only black, white, and shades of gray		30	43
b. colors as clearly as under daylight conditions		0	0
c. colors, but not as clearly as under daylight conditions		60	47
d. reds, greens, and blues only		10	10
20. What is the hardest color for our eyes to see at night from a distance?	B		
a. blue		3	
b. red		93	
c. yellow		0	
d. green		5	
20. What is the easiest color for our eyes to see at night from a distance?	D		
a. red			27
b. orange			10
c. yellow			43
d. green			20

Item (Test for Program Group)	Correct Answer	Experiment C	
		OSUTP	OSUTR
21. The most important change during dark adaptation is:	C		
a. an increase in the size of the pupil		40	
b. a change in the shape of the lens		8	
c. an increase in the amount of visual purple		38	
d. an increase in the number of rod cells		15	
21. The most important change in the eyes at night that helps soldiers to dark adapt is	C		
a. an increase in the size of the pupil			50
b. a change in the shape of the lens			0
c. an increase in the amount of visual purple			40
d. an increase in the number of rod cells			10
22. If you do not look directly at flashing strobe lights or tracer rounds, how long will your dark adaptation be affected?	D		
a. 10 seconds or less		50	43
b. 1-2 minutes		3	23
c. 5-10 minutes		0	3
d. dark adaptation will not be affected		48	30
23. Wearing military-issue sunglasses on sunny days helps you to dark adapt at night because:	A		
a. your visual purple is less likely to be "bleached out"		48	63
b. your rod cells are activated before it gets dark		10	7
c. you actually start dark adapting during the day		35	27
d. the glasses block the functioning of cone cells		5	3
[no answer]		3	0
24. A soldier with 20/20 vision can clearly see	D		
a. an object that is 20 feet high and 20 feet away		8	13
b. an object better than someone with 20/10 vision		13	7
c. 20 feet further when viewing with one eye than when viewing with two eyes		5	13
d. an object placed 20 feet away		75	67
25. Which part(s) of the eye operate under bright sunshine?	C		
a. rods and cones		23	23
b. rods only		13	23
c. cones only		65	53

Item (Test for Program Group)	Correct Answer	Experiment C	
		OSUTP	OSUTR
26. Which of the following is true if a soldier has 20/400 vision at night?	B		
a. At night, he must be 20 feet closer to see objects which are 400 feet away		20	23
b. For objects seen at 400 feet during the day, he must be 20 feet away to see them at night		80	77
27. Staring directly at an object at night:	A		
a. can make it disappear		93	97
b. can make it brighter		0	0
c. allows you to see the object's details more clearly		3	3
d. can make it seem smaller		0	0
[no answer]		5	0
28. Which of the following is a condition under which both the rods and the cones of the eye are operating?	B		
a. moonless night		8	7
b. dusk		63	67
c. cloudy nights		5	3
d. starlight		23	23
[no answer]		3	0
29. The primary reason we have no color vision, sharply reduced visual acuity, and slow reaction times under very dark conditions is that:	A		
a. The cone cells cannot function at night		58	40
b. The rod cells cannot function at night		10	13
c. The rod cells are not sensitive to small amounts of light		13	3
d. There are no cone cells on the periphery of the retina		20	43
30. What can occur if you stare at a non-moving, isolated light at night?	C		
a. the light will appear to change color		3	7
b. the light will appear to become brighter		3	0
c. the light will appear to move		93	90
d. the light will appear to become larger		3	3

Item (Test for Program Group)	Correct Answer	Experiment C	
		OSUTP	OSUTR
31. When you stare at a non-moving isolated light at night, it appears to	D		
a. move to the right or left, but not up or down		5	7
b. move up or down, but not right or left		10	3
c. move in a circular pattern for everyone		3	7
d. move differently for different people		75	83
e. flash		0	0
f. stay stationary		5	0
[no answer]		3	0

Item (Test for Program Group)	Correct Answer	Experiment C	
		OSUTP	OSUTR
32. When should you use your peripheral vision - look out of the corner of your eye - at night? **(Check <u>all</u> that apply)**			
a. to determine the color of a light	F		
True		38	
False		63	
b. to avoid being flashblinded	F		
True		43	
False		58	
c. to see a person or vehicle better	T		
True		63	
False		38	
d. to avoid obstacles	T		
True		55	
False		45	
e. to dark adapt faster	F		
True		28	
False		73	
f. when using a flashlight	F		
True		25	
False		75	
g. you should never look peripherally	F		
True		13	
False		88	
32. You should use your peripheral vision when its dark	C		
a. to determine the color of light			20
b. to avoid being flashblinded			23
c. to see a person or vehicle better			43
d. when using a flashlight			13

Item (Test for Program Group)	Correct Answer	Experiment C	
		OSUTP	OSUTR
33. When should you stare at something at night? **(Check all that apply)**			
a. to determine the color of a light	T		
True		18	
False		83	
b. to avoid being flashblinded	F		
True		3	
False		98	
c. to see a person or vehicle better	F		
True		10	
False		90	
d. to avoid obstacles	F		
True		8	
False		93	
e. to dark adapt faster	F		
True		5	
False		95	
f. when using a flashlight	T		
True		10	
False		90	
g. you should never stare	F		
True		83	
False		18	
33. You should stare at something at night when its dark:	A		
a. to determine the color of a light			27
b. to avoid being flashblinded			13
c. to dark adapt faster			43
d. to see a person or vehicle better			13
[no answer]			3

Item (Test for Program Group)	Correct Answer	Experiment C	
		OSUTP	OSUTR
34. At long distances at night, all colors, whatever their source, may appear to be white.	A		
a. True		53	37
b. False		48	63
35. If exposed to a bright light after total dark adaptation has taken place, it will take at least 30-45 minutes to regain the same level of dark adaptation.	B		
a. True		40	53
b. False		60	47
36. There are more rod cells in the retina than cone cells.	A		
a. True		58	43
b. False		43	57
37. It is easy to see blood on a casualty at night.	B		
a. True		0	7
b. False		100	93
38. If you have 20/20 vision during the day, you will also have 20/20 vision at night.	B		
a. True		13	
b. False		88	
38. If you have good vision during the day, you will also have good vision at night	B		
a. True			13
b. False			87
39. The normal blind spot is present during both the day and night.	A		
a. True		50	57
b. False		50	43
40. You can see better at night if you wear your prescription glasses, even though you may not need them in the day.	A		
a. True		83	73
b. False		18	27

Item (Test for Program Group)	Correct Answer	Experiment C	
		OSUTP	OSUTR
41. Smoking 4 to 6 hours prior to night operations may affect your dark adaptation. *a. True* b. False	A	 95 5	
41. Dark adaptation is slowed if a soldier continues to smoke just prior to night operations *a. True* b. False	A		 97 3
42. The best way to see an object on a starlit night is to look away from it a few degrees rather than directly at it *a. True* b. False * Question was deleted for Retention Test	A	 90 10	
43/42. Exposure to lightning will not greatly affect your level of dark adaptation. *a. True* b. False	A	 58 43	 40 60
44/43. Colored smoke makes a good marker at night because the different colors are clearly distinguishable. a. True *b. False*	B	 10 90	 13 87
45/44. When you wake up in the middle of the night you are already dark adapted. *a. True* b. False	A	 63 38	 60 40
46/45. Individuals dark adapt at the same rate. a. True *b. False*	B	 3 98	 0 100

Item (Test for Program Group)	Correct Answer	Experiment C	
		OSUTP	OSUTR
47. Your reaction time is slower during twilight than during daylight.	A		
a. True		83	
b. False		18	
46. Your reaction time is slower under starlight than during twilight.	A		
a. True			67
b. False			33
48/47. Looking to the side of a red light at night may result in the light appearing white.	A		
a. True		70	50
b. False		30	50
49. Under twilight conditions, it is easy to read letters as it is during the day	B		
a. True		5	
b. False		95	
*Deleted in Retention Test			

Table F2

Percentage Responding to Each Item on the Post and Retention Tests for the Text Group

[Under Experiment C the OSUTP stands for the OSUT Posttest and OSUTR stands for the OSUT Retention Test]

Item (Test for Text Group)	Correct Answer	Experiment C	
		OSUTP	OSUTR
1. It takes approx. _____ minutes for a person with normal, healthy vision to completely dark adapt	30-45		
5 minutes or less		12	26
6-10 minutes		0	3
11-19 minutes		0	11
20-29 minutes		9	3
30-45 minutes		73	54
> than 45 minutes		0	3
[no answer]		5	0
2. Which of the following enhances your ability to see at night?	D		
a. eating a candy bar for quick energy before night operations.		0	0
b. using chewing tobacco at night.		0	0
c. supplementing a balanced diet with Vitamin A.		39	23
d. reducing your exposure to intense light during the day.		59	77
[no answer]		2	0
3. Visual purple is a chemical in the rod cells of our eyes responsible for	C		
a. our ability to see colors during the day.		17	9
b. the color of our eyes.		2	3
c. our ability to see at night.		68	77
d. enabling us to directly view objects at night from great distances.		12	11

Item (Test for Text Group)	Correct Answer	Experiment C	
		OSUTP	OSUTR
4. Fatigue during night operations result in	A		
a. a tendency to stare at objects.		71	
b. the inability to see objects clearly		20	
c. a decrease in blood sugar level, which causes poor reaction time.		2	
d. a loss of color vision.		7	
4. Fatigue during night operations result in	A		
a. a tendency to stare at objects.			51
b. the inability to see objects clearly			43
c. a decrease in the ability to see distant lights			3
d. a loss of color vision			3
5. Which of the following statements is true?	B		
a. The rods are primarily responsible for day vision, and the cones are primarily responsible for night vision.		10	49
b. The rods are primarily responsible for night vision, and the cones are primarily responsible for day vision.		90	51
6. What is the best way to maintain dark adaptation when you are unexpectedly exposed to a bright light, such as a search light?	A		
a. close one eye and avoid looking directly into the lights.		83	80
b. view lights peripherally by focusing on a distant object.		0	11
c. alternate between brief periods of viewing directly and looking away.		2	0
d. slowly move your eyes around the light source in a diamond-pattern.		12	9
[no answer]		2	0

Item (Test for Text Group)	Correct Answer	Experiment C	
		OSUTP	OSUTR
7. Approximately how long will a soldier have to be exposed to a searchlight at night before it begins to seriously interfere with his dark adaptation?	B		
a. less than a minute		78	
b. 3-5 minutes		12	
c. 10-15 minutes		2	
d. 20-25 minutes		5	
[no answer]		2	
7. Approximately how long will a soldier have to look at a searchlight at night before it interferes with his dark adaptation?	A		
a. less than a minute			83
b. 3-5 minutes			9
c. 5-10 minutes			9
d. more than 10 minutes			0
8. Diamond viewing or off-center vision techniques may best be defined as follows:	C		
a. scanning a large area to maximize your field of view		20	
b. the technique used to protect your dark adaptation from bright sources of light		12	
c. looking to all sides of the object you wish to see		66	
d. a technique used to discriminate between colors at night		0	
[no answer]		2	
8. Which of the following best defines diamond viewing:	C		
a. scanning, as you would during the day, to detect objects of military interest			6
b. looking away from a light source to protect your dark adaptation from bright lights			3
c. looking to all sides of the object you wish to see			80
d. a technique for discriminating between colors at night			11

Item (Test for Text Group)	Correct Answer	Experiment C	
		OSUTP	OSUTR
9. Due to the night blind spot, which of the following objects is most likely to be missed when viewed at a distance of approximately 6 feet?	B		
a. a tank		0	
b. a hand grenade		95	
c. an enemy soldier		5	
d. a howitzer		0	
9. Due to the night blind spot, which of the following is most likely to be missed when viewed from a distance of approximately 150 feet?	C		
a. a tank			17
b. a hand grenade			40
c. an enemy soldier			37
d. a large aircraft			6
10. On a dark night, a school bus can be most easily distinguished by	B		
a. the yellow paint and black lettering on its sides		42	49
b. its shape or outline		54	46
c. the number of windows and amount of glass		0	0
d. the size and location of the red caution lights		5	6
11. The vision that may occur during the daytime under several layers of jungle canopy is comparable to the vision we have during which of the following conditions?	B		
a. night		2	9
b. twilight		71	66
c. starlight		20	20
d. no moonlight and no stars		7	6
12. What is the best degree of visual acuity we have on a moonless night?	D		
a. 20/20		15	11
b. 20/50		7	11
c. 20/100		12	20
d. 20/200		61	37
e. 20/400		5	17
[no answer]		0	3

Item (Test for Text Group)	Correct Answer	Experiment C	
		OSUTP	OSUTR
13. We have a night blind spot because:	B		
a. there are no light cells (receptors) where the optic nerve inserts in the retina		20	20
b. the very central part of the retina contains only those light cells which function during the day		39	26
c. the number of light cells in the retina decreases at night		15	20
d. the peripheral retina contains very few of the light cells which function at night		27	34
14. During the period it takes to dark adapt, your ability to see at night	B		
a. continues to improve the same amount with each minute		12	
b. is hindered at the very first, then improves fairly quickly, and then gradually gets better and better		24	
c. is hindered at the very first and then gradually gets better and better		54	
d. is poor throughout the period and only gets better at the end		10	
* Question was deleted on retention test			
50. To overcome the night blind spot, you must move your head from side to side.	B		
a. True		51	
b. False		49	
14. To overcome the night blind spot with diamond viewing, you scan by	B		
a. turning your head and moving it in a diamond pattern around the object of interest			11
b. shifting your eyes from the object of interest a few degrees and moving your eyes in a diamond pattern around it			71
c. moving both your head and your eyes in a diamond pattern around the object of interest			17
15. Diamond viewing helps you to see:	A		
a. stationary and moving targets		76	54
b. only stationary targets		22	40
c. only moving targets		2	6
16. After your eyes are thoroughly dark adapted, the exposure of one eye to bright light will result in	D		
a. a complete loss of dark adaptation in the exposed eye		5	14
b. a complete loss of dark adaptation in both eyes		15	6
c. no loss of dark adaptation to either eye		12	9
d. a loss of dark adaptation in the exposed eye for a short time		68	71

Item (Test for Text Group)	Correct Answer	Experiment C	
		OSUTP	OSUTR
17. A soldier on night operations is following others in a file and reports that the reflective tape on the back of the helmet of a soldier a few paces ahead have disappeared. Why is the soldier unable to view the tape?	A		
a. the soldier was looking directly at the tape		83	97
b. the soldier was standing too close to the person directly in front		5	0
c. there was little moonlight or starlight		2	0
d. the soldier was using peripheral vision to view the tape		10	3
18. Which of the following will interfere most seriously with dark adaptation?	D		
a. looking at the instrument panel of a vehicle		2	3
b. observing the lights of a city skyline		7	3
c. lighting a cigarette		17	23
d. 5 minutes in a tent with bright white light		73	71
19. Under twilight conditions, we are able to see	C		
a. only black, white, and shades of gray		63	43
b. colors as clearly as under daylight conditions		2	3
c. colors, but not as clearly as under daylight conditions		32	46
d. reds, greens, and blues only		2	9
20. What is the hardest color for our eyes to see at night from a distance?	B		
a. blue		7	
b. red		81	
c. yellow		2	
d. green		10	
20. What is the easiest color for our eyes to see at night from a distance?	D		
a. red			37
b. orange			6
c. yellow			49
d. green			9

Item (Test for Text Group)	Correct Answer	Experiment C	
		OSUTP	OSUTR
21. The most important change during dark adaptation is:	C		
a. an increase in the size of the pupil		49	
b. a change in the shape of the lens		7	
c. an increase in the amount of visual purple		34	
d. an increase in the number of rod cells		10	
21. The most important change in the eyes at night that helps soldiers to dark adapt is	C		
a. an increase in the size of the pupil			66
b. a change in the shape of the lens			6
c. an increase in the amount of visual purple			23
d. an increase in the number of rod cells			6
22. If you do not look directly at flashing strobe lights or tracer rounds, how long will your dark adaptation be affected?	D		
a. 10 seconds or less		20	34
b. 1-2 minutes		20	20
c. 5-10 minutes		5	6
d. dark adaptation will not be affected		56	40
23. Wearing military-issue sunglasses on sunny days helps you to dark adapt at night because:	A		
a. your visual purple is less likely to be "bleached out"		66	51
b. your rod cells are activated before it gets dark		10	20
c. you actually start dark adapting during the day		10	20
d. the glasses block the functioning of cone cells		15	9
24. A soldier with 20/20 vision can clearly see	D		
a. an object that is 20 feet high and 20 feet away		10	14
b. an object better than someone with 20/10 vision		5	17
c. 20 feet further when viewing with one eye than when viewing with two eyes		0	6
d. an object placed 20 feet away		85	63
25. Which part(s) of the eye operate under bright sunshine?	C		
a. rods and cones		15	6
b. rods only		10	31
c. cones only		76	63

Item (Test for Text Group)	Correct Answer	Experiment C	
		OSUTP	OSUTR
26. Which of the following is true if a soldier has 20/400 vision at night?	B		
a. At night, he must be 20 feet closer to see objects which are 400 feet away		20	17
b. For objects seen at 400 feet during the day, he must be 20 feet away to see them at night		81	83
27. Staring directly at an object at night:	A		
a. can make it disappear		98	97
b. can make it brighter		2	0
c. allows you to see the object's details more clearly		0	0
d. can make it seem smaller		0	0
[no answer]		0	3
28. Which of the following is a condition under which both the rods and the cones of the eye are operating?	B		
a. moonless night		12	3
b. dusk		49	51
c. cloudy nights		2	3
d. starlight		34	43
[no answer]		2	0
29. The primary reason we have no color vision, sharply reduced visual acuity, and slow reaction times under very dark conditions is that:	A		
a. The cone cells cannot function at night		63	34
b. The rod cells cannot function at night		7	20
c. The rod cells are not sensitive to small amounts of light		12	20
d. There are no cone cells on the periphery of the retina		17	26
30. What can occur if you stare at a non-moving, isolated light at night?	C		
a. the light will appear to change color		12	26
b. the light will appear to become brighter		22	0
c. the light will appear to move		61	63
d. the light will appear to become larger		5	11

Item (Test for Text Group)	Correct Answer	Experiment C	
		OSUTP	OSUTR
31. When you stare at a non-moving isolated light at night, it appears to	D		
a. move to the right or left, but not up or down		10	9
b. move up or down, but not right or left		2	9
c. move in a circular pattern for everyone		17	14
d. move differently for different people		46	43
e. flash		15	14
f. stay stationary		10	11

Item (Test for Text Group)	Correct Answer	Experiment C	
		OSUTP	OSUTR
32. When should you use your peripheral vision - look out of the corner of your eye - at night? **(Check <u>all</u> that apply)**			
a. to determine the color of a light	F		
True		34	
False		66	
b. to avoid being flashblinded	F		
True		54	
False		46	
c. to see a person or vehicle better	T		
True		59	
False		42	
d. to avoid obstacles	T		
True		39	
False		61	
e. to dark adapt faster	F		
True		27	
False		73	
f. when using a flashlight	F		
True		24	
False		76	
g. you should never look peripherally	F		
True		10	
False		90	
32. You should use your peripheral vision when its dark	C		
a. to determine the color of light			11
b. to avoid being flashblinded			29
c. to see a person or vehicle better			51
d. when using a flashlight			9

Item (Test for Text Group)	Correct Answer	Experiment C	
		OSUTP	OSUTR
33. When should you stare at something at night? **(Check all that apply)**			
a. to determine the color of a light	T		
True		29	
False		71	
b. to avoid being flashblinded	F		
True		5	
False		95	
c. to see a person or vehicle better	F		
True		7	
False		93	
d. to avoid obstacles	F		
True		2	
False		98	
e. to dark adapt faster	F		
True		15	
False		85	
f. when using a flashlight	T		
True		22	
False		78	
g. you should never stare	F		
True		54	
False		46	
33. You should stare at something at night when its dark:	A		
a. to determine the color of a light			31
b. to avoid being flashblinded			6
c. to dark adapt faster			51
d. to see a person or vehicle better			11

Item (Test for Text Group)	Correct Answer	Experiment C	
		OSUTP	OSUTR
34. At long distances at night, all colors, whatever their source, may appear to be white.	A		
a. True		32	49
b. False		68	51
35. If exposed to a bright light after total dark adaptation has taken place, it will take at least 30-45 minutes to regain the same level of dark adaptation.	B		
a. True		51	60
b. False		49	40
36. There are more rod cells in the retina than cone cells.	A		
a. True		61	51
b. False		39	49
37. It is easy to see blood on a casualty at night.	B		
a. True		2	17
b. False		98	83
38. If you have 20/20 vision during the day, you will also have 20/20 vision at night.	B		
a. True		15	
b. False		85	
38. If you have good vision during the day, you will also have good vision at night	B		
a. True			11
b. False			89
39. The normal blind spot is present during both the day and night.	A		
a. True		63	66
b. False		37	34
40. You can see better at night if you wear your prescription glasses, even though you may not need them in the day.	A		
a. True		83	71
b. False		17	29

Item (Test for Text Group)	Correct Answer	Experiment C	
		OSUTP	OSUTR
41. Smoking 4 to 6 hours prior to night operations may affect your dark adaptation. *a. True* b. False	A	 93 7	
41. Dark adaptation is slowed if a soldier continues to smoke just prior to night operations *a. True* b. False	A		 94 6
42. The best way to see an object on a starlit night is to look away from it a few degrees rather than directly at it *a. True* b. False * Question was deleted for Retention Test	A	 93 7	
43/42. Exposure to lightning will not greatly affect your level of dark adaptation. *a. True* b. False	A	 42 59	 54 46
44/43. Colored smoke makes a good marker at night because the different colors are clearly distinguishable. a. True *b. False*	B	 22 78	 31 69
45/44. When you wake up in the middle of the night you are already dark adapted. *a. True* b. False	A	 73 27	 89 11
46/45. Individuals dark adapt at the same rate. a. True *b. False*	B	 2 98	 11 89

Item (Test for Text Group)	Correct Answer	Experiment C	
		OSUTP	OSUTR
47. Your reaction time is slower during twilight than during daylight.	A		
a. True		85	
b. False		15	
46. Your reaction time is slower under starlight than during twilight.			
a. True	A		71
b. False			29
48/47. Looking to the side of a red light at night may result in the light appearing white.	A		
a. True		44	49
b. False		56	51
49. Under twilight conditions, it is easy to read letters as it is during the day	B		
a. True		5	
b. False		95	
Deleted on Retention Test			

APPENDIX G

CLASSIFICATION OF TEST ITEMS: EXPERIMENT C

Table G1
Classification of Each Test Item Used in Experiment C

Posttest Item #	Retention Test Item #	Program Topic	Importance	Program Presentation
1*	1*	DA-General	Important	Technical
2*	2*	Protect-DA	Important	Application
3*	3*	Visual Purple	Important	Technical
4	4	Protect-DA	Less Important	Technical
5*	5*	Rods and Cones	Important	Technical
6*	6*	DA and Lights	Important	Demonstration
7	7	DA and Lights	Less Important	Application
8	8	Viewing Techniques	Important	Demonstration
9	9	Viewing Techniques	Less Important	Demonstration
10*	10*	Visual Acuity	Important	Application
11*	11*	Visual Acuity	Less Important	Technical
12*	12*	Visual Acuity	Less Important	Technical
13*	13*	Blind Spot	Less Important	Technical
14		DA-General	Less Important	Application
15*	15*	Viewing Techniques	Important	Demonstration
16*	16*	DA and Lights	Important	Demonstration
17*	17*	Blind Spot	Less Important	Technical
18*	18*	DA and Lights	Less Important	Application
19*	19*	Color Perception	Less Important	Technical
20	20	Color Perception	Important	Demonstration
21*	21*	Visual Purple	Less Important	Technical
22*	22*	DA and Lights	Important	Demonstration
23*	23*	Visual Purple	Less Important	Application
24*	24*	Visual Acuity	Important	Technical

Posttest Item #	Retention Test Item #	Program Topic	Importance	Program Presentation
25*	25*	Rods and Cones	Important	Technical
26*	26*	Visual Acuity	Less Important	Application
27*	27*	Blind Spot	Important	Demonstration
28*	28*	Rods and Cones	Less Important	Technical
29*	29*	Rods and Cones	Less Important	Technical
30*	30*	Autokinesis	Important	Demonstration
31	31	Autokinesis	Less Important	Demonstration
32a-g	32	Viewing Techniques	Important	Application
33a-g	33	Viewing Techniques	Important	Application
34*	34*	Color Perception	Less Important	Application
35*	35*	DA and Lights	Less Important	Technical
36*	36*	Rods and Cones	Less Important	Technical
37*	37*	Color Perception	Less Important	Application
38	38	Visual Acuity	Important	Application
39*	39*	Blind Spot	Less Important	Technical
40*	40*	Visual Acuity	Important	Technical
41*	41*	Protect-DA	Less Important	Technical
42		Viewing Techniques	Less Important	Technical
43*	42*	DA-Lights	Less Important	Application
44*	43*	Color Perception	Less Important	Application
45*	44*	DA-General	Less Important	Application
46*	45*	DA-General	Less Important	Technical
47	46	Reaction Time	Important	Technical
48*	47*	Color Perception	Important	Demonstration
49		Visual Acuity	Important	Demonstration
50	14	Viewing Techniques	Important	Demonstration

Note. DA stands for dark adaptation. * indicates the items common to all tests in Experiments A, B and C.

Table G2

Crosswalk Between Items Classified by Important and Material and Method of Program Presentation - Experiment C - Posttest

Program Presentation	Importance of Material		Total # of Items
	Important	Less Important	
Demonstration	6, 8, 15, 16, 20, 22, 27, 30, 48, 49, 50	9, 31	13
Technical	1, 3, 5, 24, 25, 40, 47	4, 11, 12, 13, 17, 19, 21, 28, 29, 35, 36, 39, 41, 42, 46	22
Application	2, 10, 32a, 32b, 32c, 32d, 32e, 32f, 32g, 33a, 33b, 33c, 33d, 33e, 33f, 33g, 38	7, 14, 18, 23, 26, 34, 37, 43, 44, 45	27
Total # of Items	35	27	62

Note. Item numbers are cited in the cells.

Table G3

Crosswalk Between Items Classified by Important and Material and Method of Program Presentation - Experiment C - Retention Test

Program Presentation	Importance of Material		Total # of Items
	Important	Less Important	
Demonstration	6, 8, 14, 15, 16, 20, 22, 27, 30, 47	9, 31	12
Technical	1, 3, 5, 24, 25, 40, 46	4, 11, 12, 13, 17, 19, 21, 28, 29, 35, 36, 39, 41, 45	21
Application	2, 10, 32, 33, 38	7, 18, 23, 26, 34, 37, 42, 43, 44	14
Total # of Items	22	25	47

Note. Item numbers are cited in the cells.

APPENDIX H

DATA TABLES: EXPERIMENTS A AND B

Table H1
Demographic Information - Experiment A

Background	Soldier Category		
	Small-Unit Leaders	Ranger School Students	Instructors and Cadre
Mean Months in Army[a]	70.5 (54.9)	31.8 (21.7)	72.1 (47.7)
% Soldiers by Rank			
1st or 2nd Lieutenant	3.3%	26.7%	---
Specialist 3 and below	3.3%	30.0%	33.3%
Specialist 4	46.7%	43.3%	6.7%
Sergeant	33.3%	---	6.7%
Staff Sergeant	10.0%	---	53.3%
First Sergeant	3.3%	---	---

[a] *SD* in parentheses.

Table H2
Demographic Information - Experiment B

Background	Soldier Category	
	Small-Unit Leaders	Active-Reserve Leaders
Mean Months in Army[a]	82.3 (46.1)	131.0 (54.4)
% Soldiers by Rank		
Captain	---	3%
Enlisted below Specialist 4	7%	---
Specialist 4	33%	6%
Sergeant	30%	9%
Staff Sergeant	27%	82%
Sergeant First Class	3%	---
Mean Age (years)[a]	Not Available	31.9 (6.9)
Active Component	100%	47%
Reserve Component	0%	53%

[a] *SD* in parentheses.

Table H3

Previous Training and Scores on Unaided Night Vision Topics - Experiment A

Unaided Night Vision Topic	% Indicating Previous Training		Test Scores - % Items Correct	
	Program[a]	No Program[a]	Program[b] - Posttest	No Program[b] - Initial Test / Retest
General information on dark adaptation (how long it takes)	61	68	74	54/67
How dark adaptation is affected by lights	37	63	71	57/70
Viewing techniques to overcome night blind spot	39	42	84	64/79
Protecting night vision before night operations	27	32	60	51/61
Night blind spot	32	15	67	51/71
How colors are perceived at night	17	27	74	44/75
Ability to see clear, crisp images (visual acuity)	15	24	71	55/73
Visual illusions	17	17	90	48/89
How rods and cones affect night vision	12	10	64	40/79
Role of visual purple in night vision	5	10	59	38/71

[a]$n = 41$. [b]$n = 45$.

Table H4

Previous Training and Scores on Unaided Night Vision Topics - Experiment B

Unaided Night Vision Topic	% Indicating Previous Training		Test Scores - % Items Correct	
	Program	No Program	Program - Posttest	No Program - Initial Test / Retest
General information on dark adaptation (how long it takes)	68	77	65	63/75
How dark adaptation is affected by lights	52	68	64	53/71
Viewing techniques to overcome night blind spot	39	39	69	61/83
Protecting night vision before night operations	45	36	52	36/52
Night blind spot	16	19	77	49/74
How colors are perceived at night	26	13	67	49/75
Ability to see clear, crisp images (visual acuity)	23	19	60	54/75
Visual illusions	19	10	71	60/66
How rods and cones affect night vision	13	10	74	53/74
Role of visual purple in night vision	13	10	55	33/59

Note. *N* per cell is 31.

Tables H5 through H7 present the series of analyses which examined the program and soldier category effects on the total score (% items answered correctly on the posttest for the Program group and the initial test for the No Program group) and subscores on the item importance and program presentation dimensions in Experiment A. In Tables H5 through H7, the following letters are used to designate each factor:

A - Program
B - Soldier Category
C - Item Importance
D - Program Presentation

Table H5
ANOVA on Total Score With Program and Soldier Category as the Between-Subjects Factors - Experiment A

Source	MS	*df*	*F*	*p*
Program (A)	0.9363	1	84.25	.0001
Soldier Category (B)	0.0020	2	0.19	.8275
A x B	0.0029	2	0.27	.7672
S within-group error	0.0109	84		

Table H6
ANOVA With Item Importance Subscores as the Within-Subjects Factor and Program and Soldier Category as the Between-Subjects Factors - Experiment A

Source	MS	*df*	*F*	*p*
Between subjects (Not shown; examined in previous analysis; Table H5)				
Within subjects				
Importance (C)	0.6064	1	81.25	.0001
C x Program (A)	0.0257	1	3.45	.0668
C x Soldier Category (B)	0.0152	2	2.05	.1352
C x A x B	0.0007	2	0.10	.9010
S within-group error	0.0074	84		

Table H7

ANOVA With Program Presentation Subscores as the Within-Subjects Factor and Program and Soldier Category as the Between-Subjects Factors - Experiment A

Source	MS	*df*	*F*	*p*
Between subjects (Not shown; examined in previous analysis; Table H5)				
Within subjects				
Presentation (D)	0.3079	2	28.42	.0001
D x Program (A)	0.1813	2	16.73	.0001
D x Soldier Category (B)	0.0170	4	1.58	.1814
D x A x B	0.0073	4	0.68	.6040
S within-group error	0.0108	168		

Tables H8 through H10 present the series of analyses which examined the change in scores from the initial test to the retest for the No Program group in Experiment A. In Tables H8 through H10, the following letters are used to designate each factor:

A - Soldier Category
B - Initial Test and Retest (Test Time)
C - Item Importance
D - Program Presentation

Table H8

ANOVA for the No Program Group With Total Scores on the Initial Test and Retest as the Within-Subjects Factor and Soldier Category as the Between-Subjects Factor - Experiment A

Source	MS	*df*	*F*	*p*
Between subjects				
Soldier Category (A)	0.0112	2	1.12	.3343
S within-group error	0.0099	42		
Within subjects				
Initial-Retest (B)	1.1244	1	158.17	.0001
B x A	0.0069	2	0.98	.3839
S within-group error	0.0071	42		

Table H9

ANOVA for the No Program Group With Item Importance Initial and Retest Subscores as the Within-Subjects Factors and Soldier Category as the Between-Subjects Factor - Experiment A

Source	MS	*df*	*F*	*p*
Between subjects (Not shown; examined in previous analysis; Table H8)				
Within subjects (Lower order effects examined in previous analysis; Table H8)				
Importance (C)	0.4848	1	49.32	.0001
C x Soldier Category (A)	0.0043	2	0.45	.6432
S within-group error	0.0098	42		
C x Initial-Retest (B)	0.0061	1	1.35	.2512
C x B x A	0.0024	2	0.54	.5881
S within-group error	0.0045	42		

Table H10

ANOVA for the No Program Group With Program Presentation Initial and Retest Subscores as the Within-Subjects Factors and Soldier Category as the Between-Subjects Factor - Experiment A

Source	MS	*df*	*F*	*p*
Between subjects (Not shown; examined in previous analysis; Table H8)				
Within subjects (Lower order effects examined in previous analysis; Table H8)				
Presentation (D)	0.1302	2	9.23	.0002
D x Soldier Category (A)	0.0060	4	0.43	.7887
S within-group error	0.0141	84		
D x Initial-Retest (B)	0.1641	2	17.51	.0001
D x B x A	0.0028	4	0.30	.8797
S within-group error	0.0094	84		

Table H11

Mean Percentage Correct for the Program and No Program Groups on the Six Importance-Presentation Category Combinations - Experiment A

Importance of Content	Presentation of Material in Program		
	Demonstration	Technical	Application
	M (*SD*)	*M* (*SD*)	*M* (*SD*)
Program Group[a] - Posttest			
Important	82 (15)	82 (16)	69 (27)
Less Important	90 (20)	62 (16)	65 (18)
No Program Group[b] - Initial Test			
Important	53 (15)	57 (22)	63 (24)
Less Important	61 (34)	41 (11)	53 (15)
Program and No Program Groups Combined[c] (Average of posttest and initial test)			
Important	67 (21)	70 (23)	66 (26)
Less Important	76 (31)	52 (17)	59 (17)
No Program Group - Retest[b]			
Important	78 (14)	88 (16)	71 (23)
Less Important	89 (21)	67 (14)	66 (13)

Note. All importance and presentation means and standard deviations were based on individual test items. Number of items in each category: Demonstration-Important = 10; Demonstration-Less Important = 2; Technical-Important = 7; Technical-Less Important = 16; Application-Important = 4; Application-Less Important = 11.

[a]$n = 45$. [b]$n = 45$. [c]$n = 90$.

Tables H12 through H14 present the series of analyses which examined the program and soldier category effects on the total score (% items answered correctly on the posttest for the Program group and the initial test for the No Program group) and subscores on the item importance and program presentation dimensions in Experiment B. In Tables H12 through H14, the following letters are used to designate each factor:

A - Program
B - Soldier Category
C - Item Importance
D - Program Presentation

Table H12
ANOVA on Total Score With Program and Soldier Category as the Between-Subjects Factors - Experiment B

Source	MS	*df*	*F*	*p*
Program (A)	0.2982	1	40.60	.0001
Soldier Category (B)	0.0175	1	2.39	.1276
A x B	0.0075	1	1.02	.3166
S within-group error	0.0073	58		

Table H13
ANOVA With Item Importance Subscores as the Within-Subjects Factor and Program and Soldier Category as the Between-Subjects Factors - Experiment B

Source	MS	*df*	*F*	*p*
Between subjects (Not shown; examined in previous analysis; Table H12)				
Within subjects				
Importance (C)	0.2701	1	37.06	.0001
C x Program (A)	0.0280	1	3.84	.0548
C x Soldier Category (B)	0.0034	1	0.47	.4980
C x A x B	0.0123	1	1.69	.1987
S within-group error	0.0073	58		

Table H14
ANOVA With Program Presentation Subscores as the Within-Subjects Factor and Program and Soldier Category as the Between-Subjects Factors - Experiment B

Source	MS	*df*	*F*	*p*
Between subjects (Not shown; examined in previous analysis; Table H12)				
Within subjects				
Presentation (D)	0.0965	2	8.74	.0003
D x Program (A)	0.1686	2	15.26	.0001
D x Soldier Category (B)	0.0004	2	0.04	.9590
D x A x B	0.0040	2	0.36	.6968
S within-group error	0.0110	116		

Tables H15 through H17 present the series of analyses which examined the change in scores from the initial test to the retest for the No Program group in Experiment B. In Tables H15 through H17, the following letters are used to designate each factor:

A - Soldier Category
B - Initial Test and Retest (Test Time)
C - Item Importance
D - Program Presentation

Table H15
ANOVA for the No Program Group With Total Scores on the Initial Test and Retest as the Within-Subjects Factor and Soldier Category as the Between-Subjects Factor - Experiment B

Source	MS	*df*	*F*	*p*
Between subjects				
Soldier Category (A)	0.0006	1	0.06	.8061
S within-group error	0.0105	29		
Within subjects				
Initial -Retest (B)	0.6284	1	253.27	.0001
B x A	0.0004	1	0.17	.6838
S within-group error	0.0024	29		

Table H16

ANOVA for the No Program Group With Item Importance Initial and Retest Subscores as the Within-Subjects Factors and Soldier Category as the Between-Subjects Factor - Experiment B

Source	MS	*df*	*F*	*p*
Between subjects (Not shown; examined in previous analysis; Table H15)				
Within subjects (Lower order effects examined in previous analysis; Table H15)				
Importance (C)	0.3158	1	39.53	.0001
C x Soldier Category (A)	0.0133	1	1.68	.2057
S within-group error	0.0079	29		
C x Initial-Retest (B)	0.0417	1	6.74	.0147
C x B x A	0.0028	1	0.46	.5017
S within-group error	0.0006	29		

Table H17

ANOVA for the No Program Group With Program Presentation Initial and Retest Scores as the Within-Subjects Factors and Soldier Category as the Between-Subjects Factor - Experiment B

Source	MS	*df*	*F*	*p*
Between subjects (Not shown; examined in previous analysis; Table H15)				
Within subjects (Lower order effects examined in previous analysis; Table H15)				
Presentation (D)	0.0459	2	3.31	.0434
D x Soldier Category (A)	0.0025	2	0.18	.8355
S within-group error	0.0138	58		
D x Initial-Retest (B)	0.0805	2	8.69	.0005
D x B x A	0.0038	2	0.42	.6601
S within-group error	0.0009	58		

Table H16

Mean Percentage Correct for the Program and No Program Groups on the Six Importance-Presentation Category Combinations - Experiment B

Importance of Content	Presentation of Material in Program		
	Demonstration	Technical	Application
	M (*SD*)	*M* (*SD*)	*M* (*SD*)
Program Group - Posttest[a]			
Important	73 (14)	83 (17)	56 (23)
Less Important	68 (35)	63 (13)	55 (13)
No Program Group - Initial Test[b]			
Important	51 (16)	64 (18)	53 (25)
Less Important	60 (37)	44 (11)	54 (11)
Program and No Program Groups Combined[c] (Average of posttest and initial test)			
Important	62 (19)	74 (20)	54 (24)
Less Important	64 (36)	54 (15)	54 (12)
No Program Group - Retest[b]			
Important	80 (9)	87 (15)	68 (26)
Less Important	69 (25)	67 (13)	65 (13)

Note. All importance and presentation means and standard deviations were based on individual test items. Number of items in each category: Demonstration-Important = 10; Demonstration-Less Important = 2; Technical-Important = 7; Technical-Less Important = 16; Application-Important = 4; Application-Less Important = 11.

[a]n = 31. [b]n = 31. [c]n = 62.

APPENDIX I

DATA TABLES: EXPERIMENT C

Table I1
Demographic Information - Experiment C

Background	Experimental Condition	
	Program[b]	Text[c]
Mean GT Score[a]	108.78 (11.07)	105.07 (10.57)
Mean Age (years)[a]	20.80 (3.48)	20.46 (3.08)
% with at least a High School Education	63%	61%

[a]*SD* in parenthesis. [b]*n* = 40. [c]*n* = 41.

Table I2
Demographic Data on Trainees Who Were Retested and Those Who Were not Retested - Experiment C

Demographic Variable	Retested		Not Retested	
	M (SD)	*n*	*M (SD)*	*n*
	Program Condition			
Mean GT Score	109.20 (11.47)	30	107.50 (10.23)	10
Mean Age	20.63 (3.39)	30	21.30 (3.86)	10
% with HS Education	73%	30	22%	10
	Text Condition			
Mean GT Score	105.49 (9.87	35	102.67 (14.92)	6
Mean Age	19.97 (2.20)	35	23.33 (1.76)	6
% with HS Education	63%	35	50%	6

Table I3

ANOVA on Demographic Variables With Experimental Condition and Session as the Between-Subjects Factors - Experiment C

Source	*MS*	*df*	*F*	*p*
GT Score				
Condition (A)	277.45	1	2.32	.1316
Session (B)	32.37	1	0.27	.6042
A x B	12.08	1	0.10	.7513
S within-group error	119.47	77		
Age				
Condition (A)	2.29	1	0.21	.6483
Session (B)	10.27	1	0.94	.3356
A x B	0.00	1	0.00	1.0000
S within-group error	10.94	77		

Note. Chi-square test comparing the experimental conditions with the percentage of trainees with at least a high school education was nonsignificant; $\chi^2(1) = .04$, $p < .842$.

Table I4

ANOVA on Total Score With Experimental Condition and Session as the Between-Subjects Factors - Experiment C

Source	*MS*	*df*	*F*	*p*
Condition (A)	66.52	1	0.57	.4531
Session (B)	82.75	1	0.71	.4029
A x B	7.19	1	0.06	.8049
S within-group error	116.97	77		

Table I5

ANOVA on Total Score With Experimental Condition and GT Category as the Between-Subjects Factors - Experiment C

Source	*MS*	*df*	*F*	*p*
Condition (A)	66.52	1	0.98	.3243
GT Category (B)	967.55	3	14.33	.0001
A x B	421.09	3	6.23	.0008
S within-group error	67.54	73		

Table I6

ANOVA With Item Importance Subscores as the Within-Subjects Factor and Experimental Condition and Session as the Between-Subjects Factors - Experiment C

Source	*MS*	*df*	*F*	*p*
Between subjects (Not shown; examined in previous analysis; Table I4)				
Within subjects				
Importance (C)	907.26	1	13.70	.0004
C x Condition (A)	33.54	1	0.51	.4788
C x Session (B)	2.13	1	0.03	.8580
C x A x B	112.83	1	1.70	.1957
S within-group error	66.22	77		

Table I7

ANOVA With Item Presentation Subscores as the Within-Subjects Factor and Experimental Condition and Session as the Between-Subjects Factors - Experiment C

Source	*MS*	*df*	*F*	*p*
Between subjects (Not shown; examined in previous analysis; Table I4)				
Within subjects				
Presentation (C)	1164.59	2	9.99	.0001
C x Condition (A)	98.10	2	0.84	.4273
C x Session (B)	125.85	2	1.08	.3396
C x A x B	121.65	2	1.04	.3549
S within-group error	116.63	154		

Table I8

ANOVA With Item Importance Subscores as the Within-Subjects Factor and Experimental Condition and GT Category as the Between-Subjects Factors - Experiment C

Source	*MS*	*df*	*F*	*p*
Between subjects (Not shown; examined in previous analysis; Table I5)				
Within subjects				
Importance (C)	1726.51	1	24.15	.0001
C x Condition (A)	3.68	1	0.05	.8212
C x Session (B)	21.29	3	0.30	.8269
C x A x B	33.93	3	0.47	.7009
S within-group error	71.49	77		

Table I9

ANOVA With Item Presentation Subscores as the Within-Subjects Factor and Experimental Condition and GT Category as the Between-Subjects Factors - Experiment C

Source	*MS*	*df*	*F*	*p*
Between subjects (Not shown; examined in previous analysis; Table I5)				
Within subjects				
Presentation (C)	423.68	2	3.47	.0380
C x Condition (A)	99.50	2	0.81	.4353
C x Session (B)	63.67	6	0.52	.7915
C x A x B	32.90	6	0.27	.9504
S within-group error	122.14	146		

Table I10

Mean Percentage Correct on Posttest by Experimental Condition and Item Classification - Experiment C

Item Importance	Presentation of Material in Program			Importance Means
	Demonstration *M* (*SD*)	Technical *M* (*SD*)	Application *M* (*SD*)	*M* (*SD*)
Program Condition[a]				
Important	74 (16)	82 (18)	65 (11)	71 (11)
Less Important	86 (23)	65 (15)	67 (15)	67 (12)
Presentation Means	76 (15)	70 (14)	66 (10)	
Text Condition[b]				
Important	71 (19)	80 (22)	66 (13)	70 (13)
Less Important	71 (27)	64 (17)	64 (18)	65 (14)
Presentation Means	71 (17)	69 (17)	65 (12)	
Program and Text Conditions[c]				
Important	72 (18)	81 (20)	65 (12)	71 (12)
Less Important	78 (26)	64 (16)	65 (16)	66 (13)
Presentation Means	73 (16)	70 (15)	65 (11)	

Note. Means are based on sum of individual items, not subscore averages.
[a]$n = 40$. [b]$n = 41$. [c]$n = 81$.

Table I11

Correlations Between Demographic Variables and Scores on the Posttest and the Retention Test - Experiment C

Scores	Demographic Variables					
	Post Test			Retention Test		
	GT	Education	Age	GT	Education	Age
Program Condition[a]						
Total	.33*	.46**	.03	.50**	.51**	.11
Subscores						
Important	.33*	.40**	-.01	.37*	.46**	.18
Less Important	.23	.43**	.07	.51**	.40*	-.03
Demonstration	.23	.22	-.07	.29	.39*	.24
Technical	.28	.39**	.01	.28	.42*	-.04
Application	.26	.47**	.14	.62****	.33	.11
Text Condition[b]						
Total	.72****	.39*	.00	.73****	.51**	.42*
Subscores						
Important	.59****	.30	-.03	.68****	.44**	.29
Less Important	.69****	.40**	.05	.65****	.48**	.46**
Demonstration	.49**	.12	-.21	.57***	.35*	.31
Technical	.69****	.27	.01	.69****	.45**	.42*
Application	.51***	.50***	.16	.57***	.50**	.30

[a]*n* = 40 for the posttest and 30 for the retention test.
[b]*n* = 41 for the posttest and 35 for the retention test.
**p* < .05. ***p* < .01. ****p* < .001. *****p* < .0001.

Table I12

Repeated Measures ANOVA on the Total Score on All Items on the Posttest and Retention Test: Experimental Condition and GT Category as the Between-Subjects Factors and Time as the Within-Subjects Factor - Experiment C

Source	*MS*	*df*	*F*	*p*
Between subjects				
Condition (A)	11.54	1	0.09	.7703
GT (B)	2397.06	3	17.88	.0001
A x B	515.19	3	3.84	.0142
S within-group error	134.08	57		
Within subjects				
Time (C)	1226.12	1	49.19	.0001
C x A	5.11	1	0.20	.6525
C x B	44.62	3	1.79	.1593
C x A x B	27.14	3	1.09	.3613
S within-group error	24.93	57		

Table I13

Repeated Measures ANOVA on the Score for Items Common to the Posttest and Retention Test: Experimental Condition and GT Category as the Between-Subjects Factors and Time as the Within-Subjects Factor - Experiment C

Source	*MS*	*df*	*F*	*p*
Between subjects				
Condition (A)	5.43	1	0.03	.8582
GT (B)	2836.99	3	16.81	.0001
A x B	738.58	3	4.83	.0077
S within-group error	168.79	57		
Within subjects				
Time (C)	925.81	1	28.39	.0001
C x A	1.69	1	0.05	.8205
C x B	14.95	3	0.46	.7122
C x A x B	86.96	3	2.67	.0563
S within-group error	32.60	57		

Table I14

Repeated Measures ANOVA on Item Importance Subscores on Posttest and Retention Test: Experimental Condition and GT Category as the Between-Subjects Factors and Time and Importance as the Within-Subjects Factors - Experiment C

Source	*MS*	*df*	*F*	*p*
Between subjects (Not shown; examined in previous analysis; Table I12)				
Within subjects				
Importance (D)	350.25	1	2.77	.1013
D x Condition (A)	17.95	1	0.15	.6992
D x GT (B)	14.69	3	0.12	.9459
D x A x B	74.60	3	0.63	.6007
S within-group error	119.02	57		
D x C (Time)	27.74	1	0.65	.4224
D x C x A	6.03	1	0.14	.7078
D x C x B	55.21	3	1.30	.2825
D x C x A x B	77.22	3	1.82	.1542
S within-group error	42.48	57		

Note. Time effects and interactions with Factors A and B examined in previous analysis; Table I12.

Table I15

Repeated Measures ANOVA on Items Common to Posttest and Retention Test: Item Importance Subscores and Time as the Within-Subjects Factors and Experimental Condition and GT Category as the Between-Subjects Factors - Experiment C

Source	*MS*	*df*	*F*	*p*
Between subjects (Not shown; examined in previous analysis; Table I13)				
Within subjects				
Importance (D)	290.66	1	14.93	.0003
D x Condition (A)	13.84	1	0.71	.4026
D x GT (B)	7.28	3	0.37	.7719
D x A x B	9.20	3	0.47	.7025
S within-group error	19.46	57		
D x C (Time)	17.36	1	2.68	.1071
D x C x A	4.64	1	0.72	.4004
D x C x B	13.92	3	2.15	.1040
D x C x A x B	5.97	3	0.92	.4358
S within-group error	6.47	57		

Note. Time effects and interactions with Factors A and B examined in previous analysis; Table I13.

Table I16

Repeated Measures ANOVA on Item Presentation Subscores on Posttest and Retention Test: Experimental Condition and GT Category as the Between-Subjects Factors and Time and Presentation as the Within-Subjects Factors - Experiment C

Source	*MS*	*df*	*F*	*p*
Between subjects (Not shown; examined in previous analysis; Table I12)				
Within subjects				
Presentation (D)	204.47	2	1.51	.2252
D x Condition (A)	505.71	2	3.74	.0268
D x GT (B)	56.49	6	0.42	.8662
D x A x B	207.42	6	1.53	.1738
S within-group error	135.36	114		
D x C (Time)	1514.02	2	15.76	.0001
D x C x A	38.35	2	0.40	.6719
D x C x B	122.32	6	1.27	.2753
D x C x A x B	40.13	6	0.42	.8660
S within-group error	96.09	114		

Note. Time effects and interactions with Factors A and B examined in previous analysis; Table I12.

Table I17

Repeated Measures ANOVA on Items Common to Posttest and Retention Test: Item Presentation Subscores and Time as the Within-Subjects Factors and Experimental Condition and GT Category as the Between-Subjects Factors - Experiment C

Source	*MS*	*df*	*F*	*p*
Between subjects (Not shown; examined in previous analysis; Table I13)				
Within subjects				
Presentation (D)	72.31	2	3.13	.0478
D x Condition (A)	74.68	2	3.23	.0432
D x GT (B)	15.67	6	0.68	.6681
D x A x B	21.40	6	0.93	.4797
S within-group error	23.13	114		
D x C (Time)	72.49	2	5.17	.0071
D x C x A	7.03	2	0.50	.6066
D x C x B	16.63	6	1.19	.3181
D x C x A x B	14.21	6	1.01	.4197
S within-group error	14.01	114		

Note. Time effects and interactions with Factors A and B examined in previous analysis; Table I13.

Table I18

Percentage Correct for Trainees who Took Both the Posttest and the Retention Test by Experimental Condition - Experiment C

Score	Posttest		Retention Test		Both Tests	
	Program *M* (*SD*)	Text *M* (*SD*)	Program *M* (*SD*)	Text *M* (*SD*)	Program *M* (*SD*)	Text *M* (*SD*)
All Test Items on Posttest and Retention Test						
Total	70 (10)	68 (12)	64 (11)	60 (14)	67 (10)	64 (12)
Important	71 (10)	70 (12)	65 (15)	62 (17)	68 (12)	66 (14)
Less Important	69 (12)	66 (14)	63 (10)	59 (15)	66 (10)	63 (14)
Demonstration	77 (14)	71 (16)	66 (15)	58 (19)	71 (13)	64 (16)
Technical	72 (14)	70 (16)	62 (14)	58 (16)	67 (13)	64 (15)
Application	66 (10)	65 (11)	65 (14)	66 (18)	65 (10)	66 (12)
Items Common to Posttest and Retention Test						
Total	71 (12)	67 (14)	65 (11)	61 (15)	68 (11)	64 (14)
Important	78 (15)	72 (17)	68 (18)	63 (19)	73 (15)	68 (17)
Less Important	67 (13)	64 (16)	63 (10)	60 (15)	65 (10)	62 (15)
Demonstration	77 (17)	67 (19)	71 (17)	62 (20)	74 (15)	64 (17)
Technical	69 (15)	68 (17)	61 (14)	58 (15)	65 (13)	63 (15)
Application	70 (16)	65 (19)	67 (17)	67 (21)	69 (14)	66 (18)

Note. n = 30 for Program condition. n = 35 for Text condition.

Table I19

Percentage Correct on Posttest and Retention Test for Trainees Who Took Both Tests - Experiment C

Score	Posttest *M* (*SD*)	Retention Test *M* (*SD*)	Mean for Posttest and Retention Test *M* (*SD*)
All Test Items on Posttest and Retention Test			
Total	69 (11)	62 (13)	66 (11)
Important	71 (11)	63 (16)	67 (13)
Less Important	67 (13)	61 (13)	64 (12)
Demonstration	74 (15)	61 (18)	68 (15)
Technical	71 (15)	60 (15)	66 (14)
Applied	65 (10)	66 (16)	66 (11)
Items Common to Posttest and Retention Test			
Total	69 (13)	63 (13)	66 (13)
Important	75 (16)	66 (19)	70 (16)
Less Important	65 (14)	61 (13)	63 (13)
Demonstration	71 (19)	66 (19)	69 (17)
Technical	69 (16)	59 (15)	64 (14)
Applied	68 (18)	67 (19)	67 (16)

Note. *N* = 65 per cell.

Table I20

Mean Percentage Correct on All Test Items for Trainees who Took Both the Posttest and the Retention Test by GT Category - Experiment C

Score	Posttest		Retention Test		Both Tests	
	Program *M (SD)*	Text *M (SD)*	Program *M (SD)*	Text *M (SD)*	Program *M (SD)*	Text *M (SD)*
GT < 100						
Important	71 (9)	62 (13)	65 (12)	53 (13)	68 (10)	57 (12)
Less Important	71 (12)	57 (8)	60 (12)	55 (14)	66 (11)	56 (10)
Demonstration	75 (8)	59 (10)	67 (15)	48 (18)	71 (10)	54 (11)
Technical	75 (15)	59 (14)	64 (13)	52 (14)	69 (14)	55 (12)
Application	67 (7)	61 (8)	56 (10)	61 (16)	61 (7)	61 (10)
GT 100-109						
Important	65 (12)	66 (9)	56 (15)	55 (15)	61 (13)	60 (11)
Less Important	61 (13)	59 (12)	58 (8)	51 (13)	60 (9)	55 (11)
Demonstration	72 (14)	69 (17)	56 (13)	52 (19)	64 (12)	60 (16)
Technical	63 (16)	64 (12)	56 (7)	50 (11)	59 (11)	57 (9)
Application	60 (10)	60 (11)	61 (14)	58 (15)	61 (11)	59 (9)
GT 110 - 119						
Important	71 (6)	81 (8)	63 (11)	72 (7)	67 (8)	76 (5)
Less Important	67 (8)	75 (7)	66 (9)	66 (8)	67 (9)	70 (7)
Demonstration	83 (14)	79 (11)	68 (12)	67 (11)	76 (11)	73 (9)
Technical	72 (12)	82 (7)	61 (16)	67 (14)	66 (13)	75 (10)
Application	61 (8)	74 (9)	66 (6)	74 (14)	63 (4)	74 (10)
GT > 119						
Important	78 (9)	82 (7)	75 (15)	84 (11)	77 (11)	83 (8)
Less Important	75 (6)	87 (6)	72 (7)	81 (7)	73 (6)	84 (5)
Demonstration	81 (17)	86 (6)	74 (15)	80 (10)	77 (16)	83 (8)
Technical	78 (7)	92 (9)	69 (16)	80 (7)	74 (11)	86 (7)
Application	74 (8)	76 (4)	79 (11)	87 (12)	76 (5)	82 (7)

Note. n = 30 for Program condition. n = 35 for Text condition.

Table I21

Mean Percentage Correct on Common Test Items for Trainees who Took Both the Posttest and the Retention Test by GT Category - Experiment C

Score	Posttest		Retention Test		Both Tests	
	Program *M (SD)*	Text *M (SD)*	Program *M (SD)*	Text *M (SD)*	Program *M (SD)*	Text *M (SD)*
<u>GT < 100</u>						
Important	75 (10)	55 (19)	69 (16)	55 (14)	72 (11)	55 (15)
Less Important	70 (14)	54 (8)	59 (11)	54 (14)	64 (11)	54 (10)
Demonstration	72 (9)	53 (14)	73 (19)	54 (20)	73 (11)	53 (15)
Technical	73 (15)	55 (13)	64 (13)	50 (12)	69 (14)	53 (11)
Application	69 (14)	53 (16)	54 (14)	62 (20)	61 (12)	58 (15)
<u>GT 100-109</u>						
Important	70 (17)	71 (11)	59 (20)	56 (19)	65 (18)	64 (14)
Less Important	59 (15)	57 (13)	58 (8)	52 (12)	59 (10)	55 (11)
Demonstration	74 (24)	67 (19)	63 (18)	55 (19)	68 (18)	61 (15)
Technical	60 (17)	63 (12)	54 (8)	51 (11)	57 (11)	57 (9)
Application	62 (19)	60 (20)	66 (19)	57 (19)	64 (17)	59 (16)
<u>GT 110 - 119</u>						
Important	80 (16)	83 (11)	72 (19)	75 (7)	76 (17)	79 (9)
Less Important	65 (7)	73 (8)	65 (8)	67 (9)	65 (8)	70 (8)
Demonstration	83 (14)	73 (20)	78 (16)	70 (12)	80 (12)	71 (15)
Technical	69 (14)	80 (8)	60 (18)	67 (12)	65 (16)	73 (9)
Application	64 (9)	76 (8)	76 (5)	77 (15)	70 (6)	76 (10)
<u>GT > 119</u>						
Important	87 (11)	88 (7)	76 (15)	87 (11)	81 (12)	87 (8)
Less Important	74 (6)	87 (7)	69 (9)	81 (9)	72 (7)	85 (7)
Demonstration	81 (18)	83 (7)	75 (13)	85 (16)	78 (15)	84 (10)
Technical	76 (8)	91 (10)	68 (17)	79 (6)	72 (11)	85 (7)
Application	84 (11)	88 (8)	78 (13)	90 (12)	81 (6)	89 (7)

Note. n = 30 for Program condition. n = 35 for Text condition.

Change in Item Scores from Posttest to Retention Test

To determine whether the Program and Text conditions had unique effects at the individual item level, items were classified by the extent to which scores changed from the posttest to the retention test. Three categories were used, based on a *SD* of 12% points: a decrease by more than one *SD*, an increase by more than one *SD*, and no change (that is, the scores changed no more than one *SD* from posttest to retention test). As shown in Table I22, the overall pattern of change was very similar for the two conditions.

Table I22
Change in Percentage Correct on Items From Posttest to Retention Test: Experiment C

Source of Item	Direction of Change From Posttest to Retention Test: # of Items		
	Decrease by > 1 *SD*	No Change (+/- 1 *SD*)	Increase by > 1 *SD*
Unique to Program	7	7	2
Unique to Text	6	6	4
Common to Program and Text	8	18	3
Total # Items for Program	15	25	5
Total # Items for Text	14	24	7

Note. One *SD* = 12% points. The analysis was based on 45 items which could be compared across the post and retention tests. Items 14, 32a-g, 33a-g, 42, and 49 were deleted from the post test. Items 32 and 33 were deleted from the retention test.

A more interesting question was whether the same type of items fell into each of these change categories for the Program and Text conditions. No distinctly, different patterns emerged from this analysis. For example, trainees in the Program condition were not more likely than those in the Text condition to remember more important content, demonstration-related material, or certain unaided night vision topics. However, items whose scores changed in the same direction for both the Program and Text conditions (that is, items in the common category in Table I22) were more likely to be classified as testing important content, than items whose direction and degree of change were unique to the Program and Text conditions.

Finally, two items showed a large drop (at least 50% points) from posttest to retention test for both experimental conditions (items 9 and 20). Both items had been revised for the retention test. Item 9 tested what would be missed because of the blind spot from a distance of 6 feet on the posttest; what would be missed from 150 feet on the retention test. Item 20 tested what color was hardest to see at night on the posttest; what color was easiest to see at night on the retention test. Scores on the other revised items had an average decrease of 3 to 4% points only.

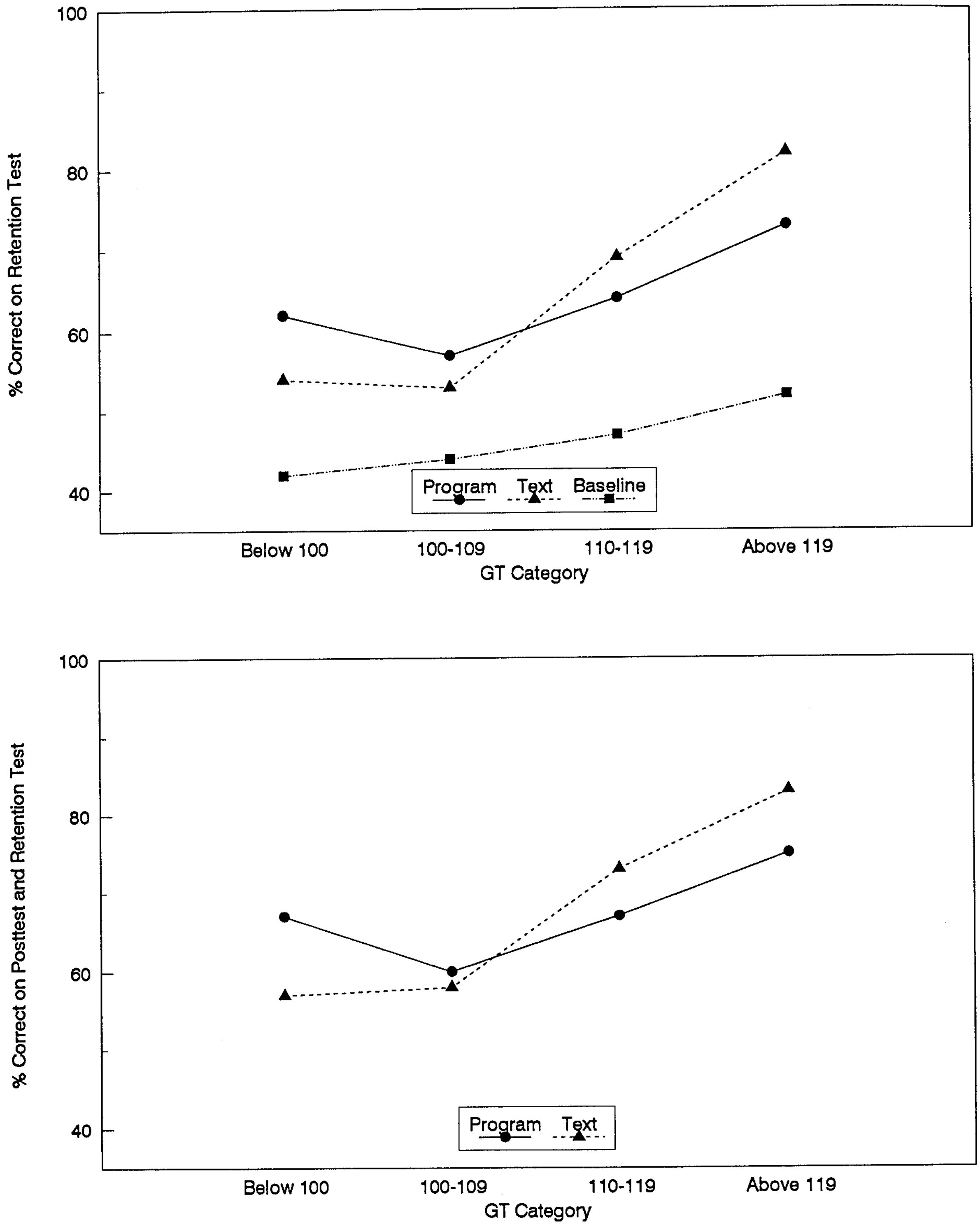

Figure I1. Interaction between experimental condition and GT category on the retention test and the average score for the posttest and retention test in Experiment C. (Baseline shown for comparison purposes only.)